WORK PLAN

FOR
WATERSHED PROTECTION
FLOOD PREVENTION

UPPER CROOKED CREEK WATERSHED

BOONE AND NEWTON COUNTIES, ARKANSAS

October 1964

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WATERSHED WORK PLAN AGREEMENT

between the

Boone County Soil and Water Conservation District
Local Organization

Newton County Soil and Water Conservation District
Local Organization

City of Harrison, Arkansas
Local Organization

State of Arkansas
(hereinafter referred to as the Sponsoring Local Organization)

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Upper Crooked Creek Watershed, State of Arkansas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Upper Crooked Creek Watershed, State of Arkansas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

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4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
Floodwater Retarding Structures 1 through 22	0	100	725,224

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 12,720 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

Boone County Soil and
Water Conservation District

Local Organization

By G. Allen Robinson M.D.

Title Chairman

Date December 17, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Boone County Soil and Water Conservation District
Local Organization

adopted at a meeting held on December 9, 1964

John Taylor
(Secretary, Local Organization)

Date December 17, 1964

Newton County Soil and
Water Conservation District

Local Organization

By Troy Fowler

Title Chairman

Date December 17, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Newton County Soil and Water Conservation District
Local Organization
adopted at a meeting held on December 4, 1964

Mose Tice
(Secretary, Local Organization)

Date December 17, 1964

City of Harrison, Arkansas
Local Organization

By B. A. Cox

Title Mayor

Date December 17, 1964

The signing of this agreement was authorized by a resolution of the governing body of the City of Harrison, Arkansas
Local Organization
adopted at a meeting held on December 17, 1964

Dorothy Peterson
(~~Secretary~~, Local Organization)
City Clerk,

Date December 17, 1964

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

UPPER CROOKED CREEK WATERSHED
Boone and Newton Counties, Arkansas

Prepared Under the Authority of the
Watershed Protection and Flood
Prevention Act, (Public Law
566, 83rd Congress, 68
Stat. 666), as amended

Prepared By:

Boone County Soil and Water Conservation District
(Cosponsor)

Newton County Soil and Water Conservation District
(Cosponsor)

City of Harrison, Arkansas
(Cosponsor)

With Assistance By:

United States Department of Agriculture
Soil Conservation Service
Forest Service

October 1964

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WATERSHED WORK PLAN

UPPER CROOKED CREEK WATERSHED
Newton and Boone Counties, Arkansas
October 1964

SUMMARY OF PLAN

General Summary

This work plan for watershed protection and flood prevention for the Upper Crooked Creek Watershed was prepared by the Boone County Soil and Water Conservation District, the Newton County Soil and Water Conservation District, and the City of Harrison, Arkansas, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666), as amended, with technical assistance from the Soil Conservation Service and the Forest Service.

The Upper Crooked Creek Watershed is the area, (56,141 acres), upstream from the confluence of White Oak Creek, a tributary of Crooked Creek. The principal tributaries are Dry Jordan, Little Dry Jordan, East Fork, and West Fork Creeks. The watershed area is divided 2,300 acres in Newton County and 53,841 acres in Boone County. The entire city of Harrison, population 6,600, is in the watershed. The rural residents, including several small farm centers, number about 2,900. There are about 490 farms in the project area, averaging 112 acres each.

Boone and Newton Counties have been declared eligible for ARA assistance due to persistent low farm income and low per capita income. The local people have organized Rural Development Councils to work toward improving the social and economic welfare of the area. Overall Economic Development Plans have been prepared for each county.

Minor floods occur from one to four times per year, usually in the late winter or during the spring. Most of the large floods have occurred in May and June. One of the first recorded floods occurred in 1889 when more than a dozen buildings in Harrison were completely destroyed and heavy damage was inflicted upon the rural areas. The most recent and the largest flood of record occurred May 7, 1961 when four lives were lost and estimated damages of $5,278,000 in the city of Harrison and $66,000 in the rural areas of the watershed were reported. The estimated average annual floodwater, sediment, erosion, and indirect damage to flood-plain values, at long-term prices, is $266,020, including $223,080 in the urban area and $42,940 in the rural areas.

There are no federal lands in the watershed.

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The work plan proposes works of improvement for the watershed to be accomplished during a five-year installation period at a total estimated cost of $4,112,928. Public Law 566 funds will pay $3,431,118, or 83 percent, and other funds will pay $681,810, or 17 percent.

Landowners and operators will install land treatment measures which will have a measurable effect on the reduction of floodwater, erosion, and sediment damages. These measures will be installed during the entire five-year period, at an estimated cost of $387,750. This includes $19,600 of Public Law 566 funds and $368,150 of other funds. Land treatment provided in recent years by local interests has cost an estimated $625,427.

This plan for structural measures was developed in a coordinated study with the Corps of Engineers and consists of twenty-two floodwater retarding structures. These measures are to be installed during the first three years of the installation period with structure numbers 20, 21, and 22 scheduled during the third year. This schedule is appropriate to permit completion of the Corps of Engineers study leading to authorization and funding of a proposed multiple-purpose structure which, if constructed, would eliminate the need for the three single-purpose structures on the East Fork tributary. The total estimated cost of structural measures is $3,725,178; the share from Public Law 566 funds is $3,411,518 and the share from other sources is $313,660.

The planned works of improvement will constitute a needed and harmonious element in the development of the White River Basin. They will reduce the average annual floodwater, erosion, and indirect damages from $226,020 to $7,805, a reduction of 97.1 percent. The level of protection provided for urban values is high. Urban damages from the occurrence of the Standard Project Flood, an approximate 325-year frequency event, is expected to be reduced from $6,360,000 to $240,000, or a 96.2 percent reduction. The urban damages from the recurrence of the flood of record, the May 7, 1961 flood, which is an approximate 115-year frequency event, is expected to be reduced from $5,278,000 to $90,000 or a 98.3 percent reduction. About 85 farms will receive direct flood prevention benefits.

The average annual benefits accruing to structural measures are distributed as follows:

Flood Prevention	
Damage Reduction	$253,600
Indirect Damage	3,240
Incidental Recreation	2,690
Secondary	26,145
Redevelopment	4,950
Total	$290,625

The average annual cost of structural measures is estimated to be $125,987. The ratio of average annual benefits to average annual cost of structural measures is 2.3 to 1.

The landowners and operators, with assistance from the Agricultural Conservation Program and other federal and state agencies, will install and maintain the land treatment measures.

The Crooked Creek Watershed Improvement District, which is being formed, with the powers of taxation and eminent domain, is expected to borrow funds needed to carry out local responsibilities from the Farmers Home Administration. A letter of intent to borrow has been sent to the Farmers Home Administration. Revenue from assessments on the benefited land will be used to repay the loan and to operate and maintain the structural measures.

DESCRIPTION OF THE WATERSHED

Physical Data

Crooked Creek rises in the northeast part of Newton County, Arkansas, and flows in a general northward direction through south-central Boone County, Arkansas, for about nine miles to the city of Harrison. From Harrison, the stream flows in a general northeast direction through ingrown meanders for about five miles to the mouth of the watershed. The mouth of the watershed is at the confluence of White Oak Creek with Crooked Creek. The principal tributaries are Dry Jordan, Little Dry Jordan, East Fork, and West Fork Creeks. The watershed has an area of 56,141 acres, or 87.7 square miles, with 2,300 acres in Newton County and 53,841 acres in Boone County. About 56 percent of the watershed is in the Ozark Highlands (ZH) Resource Area and the remaining 44 percent is in the Boston Mountain (BM) Land Resource Area. The BM soils are predominantly sandy loams and sandy clay loams. The ZH soils are cherty silt loams with some sandy loam. The soils, in general, are in fair physical condition.

The topography of the watershed is moderately rolling to mountainous. The Boston Mountain Area at the upper part of the watershed (southern and western) is underlain by sandstone and shales of the Atoka formation. Elevations range up to 2,200 feet on Boat Mountain and Sulphur Mountain on the southern boundary and about 2,000 feet above sea level on Gaither Mountain on the western boundary. The Ozark Highland Area in the central part of the watershed is chiefly underlain by limestone and cherty limestone of the Boone formation. Elevations range in general between 1,000 and 1,200 feet above mean sea level.

Forest lands comprise about 31 percent of the watershed and are relatively important to its overall hydrologic behavior. Abusive use of the woodlands has resulted in retarding the development of good forest soils for water intake and storage. Most of the woodland soils are in poor condition to perform their normal functions of intercepting, infiltrating, and percolating storm rainfall through the canopy and forest soil. Only 7 percent of the forest soils are in condition to perform these normal functions.

The present land use for the watershed is as follows:

Land Use	Acres	Percent
Cropland 1/	7,300	13
Grassland	30,315	54
Woodland	17,400	31
Miscellaneous 2/	1,126	2
Total	56,141	100

1/ Includes idle land.
2/ Includes farmsteads, urban, roads, highways, etc.

Excluding the flood-plain area in the city of Harrison, the land use in the rural flood plain is as follows: 21 percent cropland, including idle; 75 percent grassland; 3 percent woodland; and 1 percent in miscellaneous uses.

Based on a 37-year gage record at Harrison, Arkansas, the average annual rainfall is 43.59 inches. The maximum recorded rainfall of 71.0 inches occurred in 1945. The minimum was 23.1 inches in 1901.

The average rainfall by months, in inches, is as follows:

January	3.13	July	3.67
February	2.57	August	3.50
March	3.21	September	4.51
April	4.59	October	3.14
May	5.28	November	2.86
June	4.55	December	2.58

Mean temperatures range from 36.9 degrees Fahrenheit in January to 77.8 degrees in July. Extreme temperatures have been 112 degrees above zero and 24 degrees below zero. The normal frost-free period of 187 days extends from April 17 to October 21.

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Water for livestock and domestic use in the watershed is supplied by wells, springs, farms ponds, and streams. The principal water supply for the city of Harrison is obtained from springs.

Economic Data

The major part of the farm income in the watershed is from the sale of livestock and livestock products. Farm operations and cropping systems are in support of the livestock enterprise, hay, grain, and silage being the principal crops grown. Sheep, beef, and dairy cattle, and poultry are important to the area.

There are approximately 490 farms in the watershed ranging in size from a few acres up to about 800 acres, averaging 112 acres per farm.

There are no federal lands in the watershed.

The soils of the flood plain are very productive with normal flood-free yields of about 50 bushels of corn per acre and comparable yields of pasture and hay crops. Although 21 percent of the flood plain is cropland, a long rotation, including pasture and hay plants, maintains a good cover over most of the cropland and flood plain throughout the year.

The majority of the farms in the watershed are owner-operated with a minimum of hired labor being used. A long grazing season is maintained by the use of cool season plants such as fescue, orchard grass, clovers, and winter grain.

There are about 9,500 residents in this watershed including about 6,600 in Harrison and about 490 farm families and several small community centers. Urban population increased about 19 percent between 1950 and 1960. Harrison is the trade center for a large area in north-central Arkansas and south-central Missouri. It is also the southwestern gateway to the lake and recreational areas located in the two states.

Boone and Newton Counties have been declared eligible for assistance under the Area Redevelopment Act. Persistent low farm income, low per capita income, and the rural employment status substantiates their eligibility for assistance. The median income for the 2,690 rural families in Boone County in 1959 was $2,360, compared with $3,180 for the state. Although some of the larger farms are well maintained and appear quite prosperous, there are many subsistence farms. According to the 1959 census, 20 percent of the farmers had incomes under $1,000. An additional 23 percer had incomes

under $2,000. Only 24 percent of the rural labor force work in agriculture; the remainder are employed in manufacturing and other industries in Harrison and other small communities. Five percent of the rural population is unemployed.

A significant upward trend occurred in the average size and value of farm units in the county during the period 1945 to 1954. During that period, the average farm size increased from 126.4 acres to 160.6 acres and per farm value increased from $2,864 to $8,513.

Industrial development in the watershed involves a variety of products, including clothing, furniture, mattresses, timber products, and the processing of milk. The Carnation Milk Company operates a processing plant in Harrison with pickup routes throughout the watershed area and surrounding trade territory.

The watershed area is served by United States Highways 62 and 65 and Arkansas State Highways 7 and 43 and a network of county roads. The Arkansas Power and Light Company supplies the electricity; telephone service is furnished by the Boone County Telephone Company; and natural gas is supplied by Arkansas Western Gas Company.

Land Treatment Data

The Boone County and Newton County Soil and Water Conservation Districts have assisted 354, or 72 percent, of the 490 farmers in the watershed in the development of basic conservation plans for their farms. The plans cover 42,725 acres of land, or about 76 percent of the watershed area.

The major conservation treatments used by soil conservation district cooperators are associated with the use of the land for livestock enterprises. These treatments include pasture and hayland planting, rotation grazing, farm ponds, cover and green manure crops, crop residue use, and pasture proper use. It is estimated that 51 percent of the total conservation needs have been applied to date. Ten percent of the forest land has been damaged from logging operations. Most of this damage is from improperly designed haul roads and skid trails. Lacking management assistance, most of the timber stands have been overcut. Grazing is being carried out on 60 percent of the watershed and is resulting in severe damage to over 10 percent of the forest land. Removal of the protective canopy cover has resulted in accelerated oxidation of forest soils. Most of the forest floor humus has been lost in the process.

The volume of merchantable timber is only one-fourth of that which can be expected under reasonably good timber management.

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WATERSHED PROBLEMS

Floodwater Damage

The flood plain, as defined in this work plan, is that area which would be inundated by the Corps of Engineers Standard Project Flood. The total flood-plain area within the project boundaries subject to damage, downstream from the structures and exclusive of the urban area, is 2,075 acres. This 2,075 acres of agricultural land and the 265 flood-plain acres in the city of Harrison constitute the benefited area.

Minor floods occur in the Upper Crooked Creek area from one to four times per year, usually in the late winter or during spring planting season. Most of the large floods have occurred in May and June, but two recorded floods of major proportions occurred in the fall. This area has a long history of floods damaging rural and urban areas. One of the first recorded floods occurred in 1889 when more than a dozen buildings in Harrison were completely destroyed and heavy damage was inflicted upon the rural areas of the watershed.

Floodwater damage to agricultural values in the watershed is an important consideration, together with flood protection for the city of Harrison where human lives and millions of dollars of damageable values are exposed to the flood hazard. The most recent and the largest flood of record occurred May 7, 1961 when four lives were lost and estimated damages of $5,278,000 in the city of Harrison and $66,000 in the rural areas of the watershed were reported. In the last thirty years, about fourteen floods causing heavy damage in the city of Harrison and in the rural areas have occurred. Owners and operators of farm land in the flood plain suffer heavy damage from production losses and increased operating expenses caused by the annual floods that cause little damage in the urban areas. Frequency of flooding has prevented the farmers from growing the more productive crops which the flood plain would be capable of producing under flood-free conditions. The estimated average annual floodwater, sediment, erosion, and indirect damage to flood-plain values, at long-term prices, is $266,020, including $223,080 in the urban area and $42,940 in the rural areas.

Sediment Damage

Approximately 676 acres, representing 32 percent of the agricultural flood plain, located below structures, has received appreciable amounts of modern sediment deposits. These deposits range in grain size from silt and fine sand to cobbles and boulders. About 88 percent of the area damaged (598 acres) has damages ranging from 10 percent to 30 percent. The other 12 percent ranges up to 80 percent damage. Only 42 acres are damaged from 10 percent to 20 percent by swamping. The swamping is caused by overbank deposition of sediment.

Loss of productivity from new deposition and recovery of areas on which deposition has occurred appear to be approximately in equilibrium. In the absence of remedial measures to reduce sediment production and deposition, the annual sediment damage can be expected to average about $4,035.

Erosion Damage

Erosion rates are moderately low throughout the watershed. At present, the weighted average gross erosion is 1,416 tons per square mile per year. Approximately 65 percent of this rate is from sheet erosion. Roadside erosion, streambank erosion, and minor gully erosion account for the remaining 35 percent. Sheet and scour erosion erosion have damaged a total of 700 acres in the flood plain. A total of 112 acres of the flood plain have been damaged in excess of 30 percent, while 588 acres have been damaged to a lesser extent in terms of reduced productive capacity. The average annual flood-plain erosion damage without a watershed project is estimated to be $4,265.

Problems Relating to Water Management

A very small part of the watershed needs drainage which can be accomplished with individual farm drainage systems. Irrigation of crops is of minor importance.

A survey made during the summer of 1961 showed that fish resources of the watershed are principally confined to many small farm ponds. The creek dries up during the summer (except at lower reaches). The character of the creek precludes any development for fish resources in its present condition.

The present water supply for Harrison is obtained from springs, principally Jenkins and Milam Springs, located along the main stem of Crooked Creek, south and upstream from Harrison. These sources of water are subject to inundation by floods on Crooked Creek. Another source, Mitchell Spring, is located on the right bank of Crooked Creek in the northeast part of the city. The city recognizes the need for an additional water supply and has asked that municipal water supply storage be studied for inclusion in a plan for protection and development of the watershed.

PROJECTS OF OTHER AGENCIES

A local protection levee was constructed by the city of Harrison in 1936, with assistance from the Public Works Administration.

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The Corps of Engineers participated in joint studies with the Soil Conservation Service in planning and evaluation of works of improvement. During these joint studies, the Corps made tentative plans and preliminary cost estimates for a multiple-purpose structure to be located on the East Fork of Crooked Creek, and to be installed in conjunction with nineteen floodwater retarding structures. Following the completion of additional studies by the Corps and the preparation and acceptance of a Survey Report, it is expected that this multiple-purpose structure will replace three proposed floodwater retarding structures located in the headwaters of the East Fork tributary. This procedure will result in a fully coordinated plan which will meet the objectives of local interests.

A local Urban Renewal Program became very active following the May 1961 flood. The Urban Renewal Agency has acquired land, realigned levees, enlarged or constructed new floodwalls and levees, and enlarged channel capacities through Harrison at a cost of $1,713,279 (table 1A). The effects of these improvements are considered significant in furnishing adequate protection to urban values. These improvements are nearly complete with the exception of one section of left bank levee downstream from the confluence of Dry Jordan and Crooked Creek. The below-grade and standard levee in this section will be reconstructed by the Corps of Engineers to provide the needed protection.

BASIS FOR PROJECT FORMULATION

The original objectives of the watershed application were reviewed in the light of the storm of record. It was mutually agreed that the minimum acceptable level of protection must provide substantial protection against recurrence of a storm of this magnitude, which was estimated from computed discharge below Harrison to be of a 115-year frequency. This storm occurred on May 7, 1961, after work plan development investigations were underway. The high damages sustained and the loss of life that occurred as a result of this storm emphasized the need for a high level of protection. It was established that runoff from the urban area of Harrison reaches Crooked Creek for the most part through open channels and storm sewers which extend through the existing levee. Rises on Crooked Creek are of short duration and crests normally occur after the peak flows from the urban areas have reached the stream. The lower areas in town, in general, contain only low-cost improvements. For this reason, major urban damages have not resulted from inadequate local drainage but from high stages on the creeks that flow through town. Accordingly, it was recognized that the works of improvement proposed in this plan should provide a high level of protection from these high stages. The water-flow control structures were located for maximum protection of agricultural land but in order to provide a high level of protection for the urban area, it became necessary to encroach on some areas that otherwise would have benefited. This was compensated for to some extent by affording a greater level of protection to the remainder of the benefited area. The structure

sizes were planned for maximum modification of storms of infrequent occurrence. The Corps of Engineers Standard Project Flood, an approximate 325-year frequency event, was developed and used to evaluate the protection provided by the project proposals.

The city asked that consideration be given to the storage of three to five million gallons per day of municipal water supply in a site located on the East Fork of Crooked Creek. The Corps of Engineers have tentatively located a multiple-purpose structure on East Fork near its junction with Crooked Creek. It is expected that this multiple-purpose structure will replace the three Public Law 566 floodwater retarding structures (site numbers 20, 21, and 22) located in the headwaters of the East Fork. A site at the lower location which would provide additional protection for main-stem values is being evaluated by the Corps of Engineers.

The Public Law 566 plan, along with the Urban Renewal works in the city of Harrison and the planned upgrading of a short section of the lower part of the Urban Renewal levee by the Corps of Engineers or this plan modified by the multiple-purpose structure will provide adequate watershed protection and meet the sponsors' objectives.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The Boone County and Newton County Soil and Water Conservation Districts have been conducting a conservation program on cooperating farms in the watershed. This program, based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs for production and improvement in the chosen land use, is an essential part of watershed protection. The extent of needed land treatment measures which have been applied to date within the watershed represents an expenditure, initiated by landowners and operators, of approximately $625,427 (table 1A).

The accelerated application and continued maintenance of land treatment measures is important; without them, the installation of the other work plan features would not produce the expected benefits. For this reason, in addition to the presently available technical assistance, $19,600 will be made available from Public Law 566 funds to accelerate the planning of these practices.

Table 1 includes estimates of the acreage in each major land use which will receive accelerated land treatment during the five-year project installation period. These measures will be established by the landowners and operators in cooperation with the going district programs.

About 5,000 acres of cropland will be treated with a combination of measures, including cover and green manure and crop residue use, in a conservation cropping system.

About 6,400 acres of grassland will be treated with a combination of measures, including brush and weed control, pasture and hayland renovation, pasture and hayland planting, and pasture proper use.

Approximately 4,000 acres of forest land will be treated for hydrologic stand improvement. Hydrologic stand improvement will be achieved with such measures as interplanting, underplanting with release, release of preferred tree species, improvement cutting, and grazing management.

Approximately 250 farm ponds will be constructed to improve upland stock water supplies

Structural Measures

The structural measures consist of twenty-two floodwater retarding structures. The installation cost of floodwater retarding structures is estimated at $3,725,178.

The total drainage area behind the proposed dams will be 48.6 square miles, representing 55.4 percent of the total 87.7 square miles in the watershed. The permanent pools, including the areas reserved for sediment, will inundate 120 acres of flood plain. In addition, 1,679 acres of other lands will be involved in the structures.

The control (drainage area behind the structures) along the main stem of Crooked Creek, at the terminal end of reach 3 just above Harrison is 70 percent; and the control of Dry Jordan Creek, at the upstream city limits, is 70 percent. The structure and reach locations are shown on figure 5, the project map. Plans for a typical structure are illustrated by figures 1, 2, and 2A. More detailed information on quantities, costs, and design features are given in tables 1, 2, and 3.

The twenty-two structures will have an aggregate capacity of 23,759 acre-feet. The structures will have a total floodwater detention capacity of 21,116 acre-feet. The sediment storage provided will be adequate for 100-year accumulation. Floodwater detention capacity, expressed in inches of runoff from the drainage area above structures, is 8.14 inches. Sufficient detention storage can be developed at all structure sites to permit the use of vegetative spillways.

Each floodwater structure will include a drawdown slot and a drain valve in the principal spillway riser. These devices will permit manipulation of water levels for weed and mosquito control. They will also provide for fish management operation, exposure of shallow edges for waterfowl plantings and the means to supply water downstream for emergency use.

The installation of structural measures will result in the relocation of 4.3 miles of roads and appurtenances, 2 miles of primary power lines (H-frame structure), 3.9 miles of secondary power lines, 2 miles of telephone lines, and 5 buildings.

EXPLANATION OF INSTALLATION COSTS

The total installation cost of the project is estimated to be $4,112,928, of which $3,431,118 will be paid from Public Law 566 funds and $681,810 will be borne by other funds. Included in total costs are land treatment measures, $387,750, and structural measures, $3,725,178.

Land treatment costs will be shared $19,600 by Public Law 566 funds and $368,150 by other funds. Other funds include $21,500 for technical assistance through the regular program of Public Law 46 and $2,400 for technical forestry assistance on private lands by the Arkansas Forestry Commission from state funds.

To accelerate the installation of land treatment measures, Public Law 566 will pay $16,600 for technical assistance by the Soil Conservation Service and $3,000 for technical forestry assistance by the Arkansas Forestry Commission in cooperation with the United States Forest Service.

All costs of structural measures are allocated solely to flood prevention. Public Law 566 funds will pay all construction and installation services costs on these structures. The remaining costs will be borne by other funds.

Structural measures costs will be shared $3,411,518 by Public Law 566 funds and $313,660 by other funds. The Public Law 566 funds will be spent for construction and installation services costs for the twenty-two floodwater retarding structures.

Public Law 566 funds will include $2,686,294 for construction costs and $725,224 for installation services. Other funds will include $12,720 for administration of contracts and $300,940 for easements and rights-of-way. Included in easements and rights-of-way costs to be paid from other funds are $28,300 for road and bridge relocation, $76,450 for power line relocation, $2,500 for telephone line relocation, $8,000 for removal of other obstacles, $4,390 in legal fees, and $181,300 for lands.

The engineer's cost estimate and contingency allowance of 10 percent is considered realistic and provides a reasonable allowance for unexpected costs.

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The estimated schedule of obligations for the five-year installation period, covering the installation of both land treatment and structural measures, is as follows:

Schedule of Obligations

Fiscal Year	Measures	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
First	Land Treatment	5,600	75,030	80,630
	Installation Service	191,094	-	191,094
	Structures 13, 14, 15, 16, and 17	707,817	113,080	820,897
Second	Land Treatment	4,000	75,030	79,030
	Installation Service	278,014	-	278,014
	Structures 5, 6, 7, 8, 10, 11, 12, 18, and 19	1,029,877	65,435	1,095,312
Third	Land Treatment	4,000	75,030	79,030
	Installation Service	256,101	-	256,101
	Structures 9, 1, 2, 3, and 4	571,821	83,110	654,931
	Structures 20, 21, and 22 1/	376,794	52,035	428,829
Fourth	Land Treatment	4,000	75,030	79,030
Fifth	Land Treatment	2,000	68,030	70,030
	Total	3,431,118	681,810	4,112,928

1/ It is expected that a multiple-purpose structure, which has been tentatively located by the Corps of Engineers on the East Fork near its junction with Crooked Creek, will replace structures 20, 21, and 22, located in the headwaters of the East Fork.

This schedule may be adjusted from year to year on the basis of any significant changes in the plan found to be mutually desired, and in the light of appropriations and accomplishments actually made.

EFFECTS OF WORKS OF IMPROVEMENT

Reduction of Flooding

The following table shows the effect of the project, by evaluation reaches, on the average annual area flooded:

	Average Annual Area Flooded		
	Evaluation Reach 1/		
	Upstream 2/	Downstream 3/	Total
Without Project (acres)	1,406	850	2,256
With Project 4/ (acres)	162	192	354
Reduction (acres)	1,244	658	1,902
Percent Reduction	88.5	77.4	84.3

1/ Urban area omitted.
2/ Combines all reaches upstream from Harrison.
3/ Combines all reaches downstream from Harrison.
4/ Land treatment measures and twenty-two floodwater retarding structures.

The area subject to flooding, as defined by the Corps of Engineers Standard Project Flood, an approximate 325-year event, will be reduced from 2,075 acres to 1,440 acres.

About 85 landowners and operators in the rural flood-plain area will receive benefits from the flood prevention measures to be installed upstream from their land.

Installation of the twenty-two floodwater retarding structures will provide adequate protection for the watershed from all storms of record. The discharge from the May 1961 flood of record would be modified (figure 3) from a 115-year frequency discharge of approximately 54,000 c.f.s. to an 8-year frequency discharge of 21,600 c.f.s. in the urban area of Harrison (reach 4) at the mouth of Dry Jordan tributary. After installation of the proposed twenty-two floodwater retarding structures, the average annual urban damage would be reduced about 99 percent.

In agricultural reach 2, installation of the twenty-two proposed structures would modify the May 7, 1961 flood of record from an approximate 65-year frequency discharge of 38,500 c.f.s. to a 3-year frequency discharge of about 11,600 c.f.s. at the foot of reach 2. Similar modification of floods is indicated for the other five agricultural reaches by the following area inundation-frequency table for natural and modified conditions.

Evaluation Reach	Frequency in Years and Acres Inundated											
	1-year		2-year		5-year		10-year		25-year		100-year	
	Nat.	Mod.	Nat.	Mod.	Nat.	Mod.	Nat.	Mod.	Nat.	Mod.	Nat.	Mod.
Main Stem												
1	55	0	143	0	235	80	280	125	317	185	342	263
2	100	0	147	0	198	50	228	91	253	140	275	190
3	167	0	208	0	245	124	272	170	300	203	318	239
5	100	0	135	31	165	90	185	122	203	144	234	169
6	262	0	300	74	330	250	348	285	372	308	407	332
West Fork	60	0	220	17	297	112	331	169	358	217	386	256

When the land treatment and structural measures are installed, the areal extent of erosion, sediment, and swamping damages will be reduced an estimated 60 percent.

The proposed improvements will provide a unique opportunity for the development and management of fish and wildlife resources of the area. Major benefits will result from the development of fish resources. Other benefits that should accrue are the enhancement of upland game management and general recreational programs. The pools reserved for sediment in the twenty-two floodwater retarding structures will have a total of 261 surface acres of water.

The reservoirs will be stocked with largemouth bass, bluegills, redear sunfish, and channel catfish. The greatly increased fishery values accruing from the watershed project should stimulate the commercial minnow production and other enterprises related to fish and general recreation. The installation of the planned structures will stabilize the flow of water in the stream systems and periodically supply the stream with additional fish from impoundment overflows. The stream fishery will become more productive as a result of these combinations of water supply and periodic supply of fish from impoundment discharges.

The water in the sediment pools of the floodwater retarding structures attract waterfowl, especially ducks. Special management efforts will produce desirable food which will hold the ducks. Smartweeds and barnyard grass are to be grown around the shallow edges and naiads and potamogeton may be introduced.

The soil and water conservation districts will encourage owners of proposed structure sites to grow food for wintering waterfowl. This is to be accomplished by constructing a low level dike, planting the field to browntop millet, and then flooding the area during the winter. The millet also has agricultural values.

PROJECT BENEFITS

The total estimated benefits accruing to the structural measures included in this plan will amount to $290,625, annually. Of the total benefits, $264,480 are primary and $26,145 are secondary. The primary benefits are $256,840 damage reduction, $2,690 incidental recreation, and $4,950 redevelopment. None of the benefits were derived from increased acreage of allotment or surplus crops. All benefits were converted to long-term prices, as projected by ERS, September 1957.

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The increased net return to operators of flood-plain lands from restored productivity will amount to $7,910, annually. The restoration benefits are included in table 5 as damage reduction benefits.

The combined program of land treatment and structural measures will reduce the average annual floodwater, sediment, erosion, and indirect damages from $266,020 to $7,805, a reduction of 97.1 percent. The estimated average annual reduction in damage, by evaluation reaches, is as follows:

	Average Annual Damage 1/			
	Upstream 2/	Urban	Downstream 3/	Total
Without Project (dollars)	30,260	223,080	12,680	266,020
With Project (dollars)	3,510	1,930	2,365	7,805
Reduction (dollars)	26,750	221,150	10,315	258,215
Percent Reduction	88.4	99.1	81.3	97.1
Percent of Total Reduction	10.4	85.6	4.0	100.0

1/ Long-term prices, as projected by ERS, September 1957.
2/ Combines all reaches upstream from Harrison.
3/ Combines all reaches downstream from Harrison.

Damage reduction benefits accruing to the structural measures and used for project justification are as follows:

Crop and Pasture	$ 15,095
Other Agricultural	5,910
Nonagricultural	
Rural	5,700
Urban	221,150
Overbank Deposition	3,095
Flood-plain Erosion	2,650
Indirect	3,240
Total	$256,840

General recreation benefits are expected to accrue incidentally to the installation of the floodwater retarding structures. It is estimated that 12,800 persons will participate in some form of recreation, annually. Visitor-days' use was estimated, after consideration of public access, total surface area, population, and number and size of pools. Adjustments for the effect of possible deficient water supply and the lack of development for sustained use were accounted for in the estimate of number of visitor-days. Only visits from the general public or organized groups were considered in arriving at an estimate of visitor-days, annually. These estimates were based on experienced use of similar projects. Principal recreation uses will include fishing, boating, hunting, swimming, frog gigging, and picnicking and camping. Since facility development is expected to be minimal, the gross value of recreation was estimated at 50 cents per visitor-day. Associated costs, including the cost of minimal development

and operation and maintenance, were deducted to arrive at the net benefits. Net benefits were discounted to account for a five-year delay in resource development. Benefits were further discounted to account for the diminishing desirableness of the structures because of accumulated sediment. It was assumed that benefits would cease by the eightieth year. The estimated value of recreation is expected to be $2,690, annually. Specialized recreation activity is not expected to occur.

Redevelopment benefits resulting from the employment of local labor used in project construction and operation and maintenance are estimated to be $4,950, annually. These benefits were confined to unemployed and underemployed local labor. The portion of the benefits that result from operation and maintenance was treated as a decreasing annuity for twenty years. Appropriate discounting was used to bring these benefits to present worth. Redevelopment benefits were used for project justification.

Secondary benefits from a national viewpoint were not considered in the economic evaluation. Secondary benefits amounting to $26,145 were used in project justification.

Damage reduction benefits resulting from the installation of land treatment measures will approximate $1,375, annually. These benefits were not used in project justification.

In addition to the benefits for which a monetary value can be assigned, substantial increases are expected in opportunities which will relieve underemployment, promote investment in both the urban and rural economies, provide a greater opportunity for the expansion of locally owned businesses, and permit shifts in agricultural and nonagricultural resources to meet future demands. The total effects of the project will provide better living conditions, increase security, and preserve the family-farm pattern of American agriculture.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (amortized installation cost plus operation and maintenance costs) is estimated to be $125,987. The structural measures are expected to produce annual primary benefits of $264,480, or $2.10 for each dollar of cost. The ratio of total average annual benefits ($290,625) to average annual cost of structural measures ($125,987) is 2.3 to 1 (table 6).

PROJECT INSTALLATION

The watershed project is planned for a five-year installation period. Land treatment measures will be established throughout the entire period by farmers, in cooperation with the local soil and water conservation districts. The districts, with additional help from the Soil Conservation

Service and the Arkansas Forestry Commission, in cooperation with the United States Forest Service, will assist with the planning and application of these measures. The assistance will be accelerated to assure application of planned measures within the project installation period. The Soil Conservation Service will provide the additional technical assistance for conservation planning, land use determination, application assistance for cropland and pasture practices, and appropriate application assistance for woodland practices. The Arkansas Forestry Commission, in cooperation with the United States Forest Service, will assign foresters who have been trained in watershed management to help install the planned forestry measures. The foresters will schedule their work during the installation period to insure maximum benefits to the watershed project.

The Newton County and Boone County Soil and Water Conservation Districts will assume active leadership in getting the land treatment program installed. The supervisors of the soil and water conservation districts, by scheduled meetings and individual contacts, will encourage watershed farmers to establish complete soil and water conservation programs on their farms.

The Newton County and the Boone County Agricultural Stabilization and Conservation Committees will cooperate with the governing bodies of the soil and water conservation districts by selecting those Agricultural Conservation Program practices which will accomplish the conservation objectives in the shortest possible time.

The Agricultural Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings; preparing radio, television, and press releases; and using other methods of getting information to the watershed landowners and operators.

Structural measures will be established during the first three years of the installation period. Floodwater retarding structures 20, 21, and 22 are scheduled for construction last to allow for the completion of the Corps of Engineers evaluation studies of the proposed multiple-purpose structure on the East Fork of Crooked Creek. Structures 20, 21, and 22 will not be installed under the Public Law 566 program if the multiple-purpose structure is authorized for construction by the Corps of Engineers. The installation of structural measures will require acquisition of appropriate land, easements, and rights-of-way for all structural measures.

The Crooked Creek Watershed Improvement District, which is being formed under authority of Act 329 of the Acts of the General Assembly of the State of Arkansas, will have all of the necessary rights to discharge local responsibility.

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All structural measures are in one construction unit. The installation of these measures will be contingent upon the following conditions:

1. Adequate land treatment above the floodwater retarding structures has been installed either before or concurrently with the installation of the structural measures.

2. All land, easements, and rights-of-way have been obtained for structural measures or a substantial part have been obtained and a written statement has been furnished by the improvement district that its right of eminent domain will be used, if necessary, to secure the remainder within the project installation period and that sufficient funds are available for this purpose.

3. The contracting agency is prepared to discharge its responsibility as contracting agency.

4. The project agreements have been executed.

5. Operation and maintenance agreements have been executed.

The Soil Conservation Service will provide technical assistance in design, preparation of contract payment estimates, final inspections, execution of certificates of completion, and related tasks for the establishment of planned structural measures.

Through a cooperative agreement with the United States Fish and Wildlife Service, the sediment pools of the floodwater retarding structures will be stocked with the correct species and proportion of fish. The eradication of unwanted species in the streams at and above the structures will precede the stocking. As structures are completed, existing water will be treated with rotenone to eliminate undesirable native fish. Sport fish to stock the impoundments will be ordered by the soil and water conservation districts through the United States Fish and Wildlife Service. Fish management plans will be set up for each body of water.

Good fish management programs in newly built farm ponds and in existing ponds suitable for renovation will be stressed as part of the accelerated assistance to district cooperators.

FINANCING PROJECT INSTALLATION

Federal assistance will be provided under authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83rd Congress, 68 Stat. 666), as amended. This assistance is subject to appropriation of funds.

The cost of land treatment measures will be financed by the owners and operators of the land with aid from the Agricultural Conservation Program

and other state and federal programs. The cost of most of the technical application assistance for the forest land treatment measures will be financed by the Arkansas Forestry Commission and Public Law 566 funds. If the state is unable to furnish the funds for the first year of the project installation, Public Law 566 funds may provide the entire cost with the cost shared during the remainder of the installation period. The technical assistance cost for conservation planning, land use determination, and appropriate application assistance for woodland practices will be financed from the going Soil Conservation Service program (Public Law 46) and Public Law 566 funds. Public Law 566 funds are provided only for the acceleration of needed land treatment.

The Crooked Creek Watershed Improvement District which is being formed will have the power to secure and repay loans, assess benefits, and levy taxes. The needed land rights will be secured, if possible, by contributions from owners. The improvement district will have the power to acquire the needed rights with just compensation, if necessary.

The local sponsors have sent a letter to the State Office of the Farmers Home Administration, Little Rock, Arkansas, setting out the efforts being made to form the improvement district and the intention of the beneficiaries, through the improvement district, to borrow monies under Public Law 566 for carrying out local responsibilities. Funds for the repayment of this loan will be obtained from taxes levied on the benefited area.

Public Law 566 funds will finance the construction cost and the installation service cost incurred by the Soil Conservation Service in the installation of the structural measures.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by landowners and operators, cooperating with the local soil and water conservation districts. Representatives of the districts and the Soil Conservation Service will make periodic inspections of land treatment measures, and the districts will encourage farmers to perform needed maintenance.

The twenty-two floodwater retarding structures will be operated and maintained at an estimated annual cost of $3,950 (based on long-term price levels) by the Crooked Creek Watershed Improvement District, being formed. Funds for paying maintenance costs will be obtained from taxes levied on the benefited area. Maintenance will be done with contributed labor, district-owned equipment, by contract or force account, or a combination of these methods. The need for maintenance will be determined by inspections at least annually and as needed. The inspection of the floodwater retarding structures will include the condition of the principal spillway and its appurtenances, the emergency

spillway, the earth fill, the vegetative cover of the earth fill and emergency spillway, and the fences and gates installed as part of the structures

Provisions will be made for free access of representatives of the sponsoring local organizations and federal agencies to inspect and for the improvement district to provide maintenance of structural measures and their appurtenances at any time.

The sponsoring local organizations will maintain a record of all maintenance inspections and maintenance performed and have the record available for inspection by the Soil Conservation Service. They fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of invitations to bid on the construction of the structural measures.

The city of Harrison is fully aware of the need for continued maintenance of zoning regulations on the control of the use of the remaining flood-plain areas. The city, through existing authority, will prevent the encroachment on Crooked Creek and tributaries within the city limits. The city will provide leadership in preventing similar unwarranted development along Crooked Creek and tributaries outside, but adjacent to, the city as urban growth occurs.

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TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Upper Crooked Creek Watershed, Arkansas

Installation Cost Item	Unit	Number to be Applied	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other Funds	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	5,000	-	103,550	103,550
Grassland	Acre	6,400	-	225,400	225,400
Technical Assistance 2/			16,600	21,500	38,100
SCS Subtotal			16,600	350,450	367,050
Forest Service					
Woodland	Acre	4,000	-	15,300	15,300
Technical Assistance			3,000	2,400	5,400
FS Subtotal			3,000	17,700	20,700
TOTAL LAND TREATMENT			19,600	368,150	387,750
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures 1 through 22	No.	22	2,686,294	-	2,686,294
SCS Subtotal			2,686,294	-	2,686,294
Installation Services					
Soil Conservation Service					
Engineering Services			483,531	-	483,531
Other			241,693	-	241,693
SCS Subtotal			725,224	-	725,224
Subtotal - Installation Services			725,224	-	725,224
Other Costs					
Land, Easements, and Rights-of-Way			-	300,940	300,940
Administration of Contracts			-	12,720	12,720
Subtotal - Other			-	313,660	313,660
TOTAL STRUCTURAL MEASURES			3,411,518	313,660	3,725,178
TOTAL PROJECT			3,431,118	681,810	4,112,928
SUMMARY					
Subtotal SCS			3,428,118	664,110	4,092,228
Subtotal FS			3,000	17,700	20,700
TOTAL PROJECT			3,431,118	681,810	4,112,928

1/ Price Base: 1961.
2/ Includes conservation planning assistance on all land use, application assistance on cropland and pasture, and appropriate application assistance on woodland.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Upper Crooked Creek Watershed, Arkansas

Measures	Unit	Number Applied to Date	Total Cost 1/ (dollars)
LAND TREATMENT			
Cover and Green Manure Crops	Acre	2,000	14,000
Crop Residue Use	Acre	4,114	5,142
Grasses and Legumes in Rotation	Acre	2,500	52,500
Pasture and Hayland Renovation	Acre	13,604	53,736
Pasture and Hayland Planting	Acre	15,719	330,099
Farm Ponds	No.	675	168,750
Timber Stand Improvement	Acre	70	700
Tree Planting	Acre	27	500
Total Land Treatment		XXXXXX	625,427
STRUCTURAL MEASURES			
Levee, Channel, and Floodwall Rehabilitation	Feet	5,000	1,713,279 2/
Total Structural Measures		XXXXXX	1,713,279
TOTAL ALL MEASURES		XXXXXX	2,338,706

1/ Price Base: 1961.
2/ Urban Renewal work including the following cost: land rights - $1,040,129; pressure conduits - $147,500; appurtenant drainage structures - $215,650; bridge construction - $90,000; and channel, floodwall, and levee construction - $220,000.

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Upper Crooked Creek Watershed, Arkansas

(Dollars) 1/

Structure Site Number	Installation Costs - P. L. 566 Funds				Installation Costs - Other Funds			Total Installation Costs
	Construction	Installation Services: Engineering	Installation Services: Other Funds	Total P. L. 566 Funds	Adm. of Contracts	Easements and R/W	Total Other	
Floodwater Retarding Structures								
1	49,764	8,958	4,477	63,199	250	2,785	3,035	66,234
2	71,660	12,899	6,447	91,006	360	5,330	5,690	96,696
3	164,943	29,690	14,841	209,474	840	16,840	17,680	227,154
4	91,451	16,461	8,228	116,140	360	18,050	18,410	134,550
5	222,691	40,084	20,036	282,811	1,050	16,710	17,760	300,571
6	175,557	31,600	15,795	222,952	840	5,950	6,790	229,742
7	98,953	17,811	8,903	125,667	480	3,195	3,675	129,342
8	101,816	18,327	9,160	129,303	480	3,685	4,165	133,468
9	194,003	34,920	17,455	246,378	720	37,575	38,295	284,673
10	78,434	14,118	7,057	99,609	360	2,630	2,990	102,599
11	69,715	12,549	6,272	88,536	360	2,070	2,430	90,966
12	142,022	25,564	12,778	180,364	720	18,295	19,015	199,379
13	94,547	17,018	8,506	120,071	480	3,155	3,635	123,706
14	309,690	55,744	27,864	393,298	1,500	93,270	94,770	488,068
15	88,002	15,840	7,918	111,760	400	3,570	3,970	115,730
16	86,709	15,607	7,802	110,118	390	3,920	4,310	114,428
17	128,872	23,197	11,595	163,664	600	5,795	6,395	170,059
18	65,132	11,724	5,860	82,716	250	3,005	3,255	85,971
19	75,539	13,597	6,797	95,933	360	4,995	5,355	101,288
20	120,254	21,646	10,820	152,720	600	17,140	17,740	170,460
21	78,640	14,155	7,076	99,871	360	3,835	4,195	104,066
22	177,900	32,022	16,006	225,928	960	29,140	30,100	256,028
TOTAL	2,686,294	483,531	241,693	3,411,518	12,720	300,940	313,660	3,725,178

1/ Price Base: 1963.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Upper Crooked Creek Watershed, Arkansas

Item	Unit	Structure Number 1	2	3	4	5 1/	6	7	8
Drainage Area	Sq. Mi.	0.67	1.08	3.82	2.81	4.44	2.31	0.81	1.03
Storage Capacity									
Sediment Pool	Ac. Ft.	12	20	122	90	142	39	14	18
Sediment Reserve (Below Riser)	Ac. Ft.	12	19	122	90	142	39	14	17
Sediment in Detention Pool	Ac. Ft.	7	12	69	51	79	23	8	10
Floodwater	Ac. Ft.	250	489	1,528	1,497	2,012	1,033	366	467
Total	Ac. Ft.	281	540	1,841	1,728	2,375	1,134	402	512
Surface Area									
Sediment Pool	Acre	4	6	29	26	22	8	4	5
Sediment Reserve	Acre	6	10	46	40	31	12	5	7
Floodwater Pool	Acre	30	53	141	155	145	60	31	37
Volume of Fill	Cu. Yd.	39,000	80,500	194,800	87,000	340,000	265,230	129,470	132,580
Elevation Top of Dam	Foot	1,180.6	1,201.6	1,233.1	1,218.9	1,241.5	1,246.0	1,224.4	1,211.5
Maximum Height of Dam	Foot	32	35	39	34	54	54	43	38
Emergency Spillway									
Crest Elevation	Foot	1,176.0	1,198.1	1,229.1	1,215.6	1,237.4	1,241.8	1,220.7	1,207.9
Bottom Width	Foot	25	50	175	50	175	100	30	35
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		2.7	1.4	2.0	1.0	1.4	1.4	1.4	1.4
Average Curve No. - Cond. II		72	72	72	72	72	72	72	72
Emergency Spillway Hydrograph									
Storm Rainfall (6-hour)	Inch	10.0	11.5	11.0	11.2	10.9	11.2	11.6	11.5
Storm Runoff	Inch	6.5	7.9	7.4	7.6	7.3	7.6	8.0	7.9
Velocity of Flow (Vc) 3/	Ft./Sec.	0	0	0	0	0	0	0	0
Discharge Rate	C.F.S.	0	0	0	0	0	0	0	0
Maximum Water Surface Elev. 3/	Foot	-	-	-	-	-	-	-	-
Freeboard Hydrograph									
Storm Rainfall (6-hour)	Inch	20.80	20.55	19.60	19.90	19.50	20.00	20.70	20.60
Storm Runoff	Inch	16.80	16.66	15.60	15.90	15.50	16.00	16.70	16.60
Velocity of Flow (Vc) 3/	Ft./Sec.	9.3	8.1	8.7	7.9	8.9	8.9	8.3	8.2
Discharge Rate 3/	C.F.S.	622	831	3,427	760	3,808	2,215	540	603
Maximum Water Surface Elev. 3/	Foot	1,180.6	1,201.6	1,233.1	1,218.9	1,241.5	1,246.0	1,224.4	1,211.5
Principal Spillway									
Capacity - low-stage	C.F.S.	34	54	191	140	213	115	40	35
Capacity Equivalents									
Sediment Volume	Inch	0.87	0.89	1.54	1.54	1.53	0.82	0.83	0.82
Detention Volume	Inch	7.00	8.50	7.50	10.00	8.50	8.40	8.50	8.50
Spillway Storage	Inch	5.11	3.55	2.93	3.68	2.38	2.50	3.76	3.95
Class of Structure		b	b	b	b	b	b	b	b

Explanation of footnotes appears on page 27.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES (continued)

Upper Crooked Creek Watershed, Arkansas

Item	Unit	Structure Number 9 1/4/	10	11	12	13	14	15 1/	16 1/
Drainage Area	Sq. Mi.	8.58	0.55	0.57	1.69	0.74	6.46	0.70	0.77
Storage Capacity									
Sediment Pool	Ac. Ft.	155	10	10	31	14	117	12	13
Sediment Reserve (Below Riser)	Ac. Ft.	154	10	9	30	13	116	12	13
Sediment in Detention Pool	Ac. Ft.	94	6	6	19	8	71	7	8
Floodwater	Ac. Ft.	2,884	222	274	764	397	3,101	335	290
Total	Ac. Ft.	3,287	248	299	844	432	3,405	366	324
Surface Area									
Sediment Pool	Acre	50	4	3	8	4	25	4	4
Sediment Reserve	Acre	68	6	4	12	5	44	5	5
Floodwater Pool	Acre	285	25	19	57	31	230	34	28
Volume of Fill	Cu. Yd.	204,700	87,360	75,060	213,925	121,830	329,180	86,750	85,300
Elevation Top of Dam	Foot	1,131.9	1,193.5	1,305.9	1,172.3	1,226.0	1,202.2	1,206.9	1,228.8
Maximum Height of Dam	Foot	42	36	45	52	49	55	34	38
Emergency Spillway									
Crest Elevation	Foot	1,126.5	1,190.0	1,301.2	1,167.3	1,220.9	1,196.7	1,201.9	1,223.7
Bottom Width	Foot	400	43	25	180	70	400	80	120
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/		3.7	2.0	1.1	1.4	1.0	1.1	1.1	2.7
Average Curve No. - Cond. II		72	72	72	72	72	72	72	72
Emergency Spillway Hydrograph									
Storm Rainfall (6-hour)	Inch	10.5	11.7	11.6	13.0	13.3	12.1	13.3	13.3
Storm Runoff	Inch	6.9	8.0	8.0	9.3	9.6	8.4	9.5	9.5
Velocity of Flow (V_c) 3/	Ft./Sec.	4.3	0	0	0	0	0	3.65	3.4
Discharge Rate	C.F.S.	975	0	0	0	0	0	120	146
Maximum Water Surface Elev. 3/	Foot	1,126.5	-	-	-	-	-	1,202.6	1,224.4
Freeboard Hydrograph									
Storm Rainfall (6-hour)	Inch	18.72	20.90	20.80	32.50	33.30	30.20	33.30	33.22
Storm Runoff	Inch	14.75	16.90	16.80	28.20	29.00	26.00	29.00	28.96
Velocity of Flow (V_c) 3/	Ft./Sec	10.2	8.0	9.5	9.8	10.0	10.5	10.0	10.0
Discharge Rate 3/	C.F.S.	13,090	680	681	5,330	2,212	14,477	2,405	3,705
Maximum Water Surface Elev. 3/	Foot	1,131.9	1,193.5	1,305.9	1,172.3	1,226.0	1,202.2	1,206.9	1,228.8
Principal Spillway									
Capacity - low-stage	C.F.S.	967	28	29	84	37	323	35	38
Capacity Equivalents									
Sediment Volume	Inch	0.88	0.89	0.82	0.89	0.89	0.88	0.83	0.83
Detention Volume	Inch	6.30	7.50	9.00	8.50	10.00	9.00	9.00	7.00
Spillway Storage	Inch	4.06	2.91	3.12	3.51	4.51	3.79	5.30	3.98
Class of Structure		b	b	b	c	c	c	c	c

Explanation of footnotes appears on page 27.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES (continued)

Upper Crooked Creek Watershed, Arkansas

Item	Unit	Structure Number 17	18	19	20 4/	21	22	Total
Drainage Area	Sq. Mi.	1.94	0.54	1.33	2.28	0.82	4.67	48.61
Storage Capacity								
Sediment Pool	Ac. Ft.	33	10	24	41	14	84	1,025
Sediment Reserve (Below Riser)	Ac. Ft.	33	9	24	41	14	84	1,017
Sediment in Detention Pool	Ac. Ft.	19	5	15	25	8	51	601
Floodwater	Ac. Ft.	932	288	467	1,034	370	2,116	21,116
Total	Ac. Ft.	1,017	312	530	1,141	406	2,335	23,759
Surface Area								
Sediment Pool	Acre	7	3	7	16	4	18	261
Sediment Reserve	Acre	11	5	11	26	6	27	392
Floodwater Pool	Acre	55	30	50	120	37	146	1,799
Volume of Fill	Cu. Yd.	185,510	68,200	86,400	105,730	88,000	239,620	3,246,145
Elevation Top of Dam	Foot	1,202.5	1,136.2	1,155.9	1,168.0	1,262.0	1,242.3	XXXXXXXXX
Maximum Height of Dam	Foot	53	40	36	33	42	50	XXXXXXXXX
Emergency Spillway								
Crest Elevation	Foot	1,197.5	1,131.2	1,150.8	1,163.5	1,258.5	1,238.3	XXXXXXXXX
Bottom Width	Foot	200	50	50	200	40	160	XXXXXXXXX
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	XXXXXXXXX
Percent Chance of Use 2/		1.1	1.0	3.1	1.4	1.4	1.4	XXXXXXXXX
Average Curve No. - Cond. II		72	72	72	72	72	72	XXXXXXXXX
Emergency Spillway Hydrograph								
Storm Rainfall (6-hour)	Inch	12.9	13.4	9.8	11.3	11.6	10.9	XXXXXXXXX
Storm Runoff	Inch	9.2	9.6	6.3	7.7	8.0	7.3	XXXXXXXXX
Velocity of Flow (V_c) 3/	Ft./Sec	0	0	0	0	0	0	XXXXXXXXX
Discharge Rate	C.F.S.	0	0	0	0	0	0	XXXXXXXXX
Maximum Water Surface Elev. 3/	Foot	-	-	-	-	-	-	XXXXXXXXX
Freeboard Hydrograph								
Storm Rainfall (6-hour)	Inch	32.30	33.50	20.40	20.05	20.70	19.40	XXXXXXXXX
Storm Runoff	Inch	28.00	29.20	16.40	16.10	16.70	15.40	XXXXXXXXX
Velocity of Flow (V_c) 3/	Ft./Sec.	10.0	10.0	10.0	9.3	8.2	8.8	XXXXXXXXX
Discharge Rate 3/	C.F.S.	6,332	1,589	1,592	5,017	687	3,327	XXXXXXXXX
Maximum Water Surface Elev. 3/	Foot	1,202.5	1,136.2	1,155.9	1,168.0	1,262.0	1,242.3	XXXXXXXXX
Principal Spillway								
Capacity - low-stage	C.F.S.	97	27	66	388	41	233	XXXXXXXXX
Capacity Equivalents								
Sediment Volume	Inch	0.82	0.83	0.89	0.88	0.82	0.88	XXXXXXXXX
Detention Volume	Inch	9.00	10.00	6.60	8.50	8.50	8.50	XXXXXXXXX
Spillway Storage	Inch	2.86	6.00	3.46	5.01	3.50	2.51	XXXXXXXXX
Class of Structure		c	c	b	b	b	b	XXXXXXXXX

1/ Estimated from incomplete survey data.
2/ Based on regional analysis of gaged runoff and exceeds the minimum 6-hour volume set forth in Washington Engineering Memorandum 27. No allowance for release considered.
3/ Maximum during passage of hydrograph
4/ Exclusive of watershed from which runoff is controlled by other structures in series. Entire drainage area considered in design of the emergency and principal spillways.

TABLE 4 - ANNUAL COST

Upper Crooked Creek Watershed, Arkansas

(Dollars)

Evaluation Unit	Amortization of Installation Costs 1/	Operation and Maintenance Costs 2/	Total
Floodwater Retarding Structures 1 through 22	122,037	3,950	125,987
TOTAL	122,037	3,950	125,987

1/ Based on 1963 prices, amortized for 100 years at 3.125 percent interest.
2/ Long-term prices, as projected by ERS, September 1957.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Upper Crooked Creek Watershed, Arkansas
(Dollars) 1/

Item	Estimated Average Annual Damages: Without Project	With Project	Damage Reduction Benefits
Floodwater			
Crop and Pasture	17,235	2,020	15,215
Other Agricultural	7,030	815	6,215
Nonagricultural			
Rural	6,475	450	6,025
Urban	223,080	1,930	221,150
Subtotal	253,820	5,215	248,605
Sediment			
Overbank Deposition	4,035	575	3,460
Erosion			
Flood-plain Scour	4,265	1,475	2,790
Indirect	3,900	540	3,360
TOTAL	266,020	7,805	258,215

1/ Price Base: Long-term prices, as projected by ERS, September 1957.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Upper Crooked Creek Watershed, Arkansas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost 4/	Benefit-Cost Ratio
	Flood Prevention						
	Damage Reduction	Incidental Recreation 2/	Redevelopment	Secondary	Total		
Floodwater Retarding Structures 1 through 22	256,840	2,690	4,950	26,145	290,625	125,987	2.3:1
TOTAL	256,840 3/	2,690	4,950	26,145	290,625	125,987	2.3:1

1/ Long-term prices as projected by ERS, September 1957.
2/ Recreation benefits are incidental to the installation of structures.
3/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $1,375, annually.
4/ From table 4.

INVESTIGATIONS AND ANALYSES

The Soil Conservation Service on September 30, 1954 received an application for assistance for developing a work plan for watershed protection, flood prevention, and municipal water supply storage under Public Law 566, as amended.

On August 31, 1959, the state recommended a planning priority for the watershed. The Soil Conservation Service, in keeping with the January 19, 1959 agreement between the Corps of Engineers and the Soil Conservation Service, advised the Corps of their intention to initiate planning in the watershed and suggested a conference to consider the desirability of a joint study. This conference was held on August 5, 1960.

At this meeting, the provisions of the agreement on participation in urban flood protection between the Corps of Engineers and the Soil Conservation Service were discussed. The following conclusions were reached during the conference:

1. The Corps of Engineers and the Soil Conservation Service were agreeable to a cooperative study within the limits of available resources to a plan to assist the local interests in a solution to their problem.

2. The cooperative study would begin with an inventory of data available in the office of the Corps of Engineers from previous studies of flood protection for the city of Harrison.

3. Following the inventory, mutually acceptable decisions would be reached on a division of responsibility for future planning.

4. Based on the decision reached in item 3, the Corps of Engineers will request funds for their joint participation in the study.

5. It was generally agreed that structural measures to be studied by the Corps of Engineers would be limited to levees, floodwalls, and channel improvements for protection in the city of Harrison.

On October 18, 1960, the conference, as planned in item 3 above, was held. As a result of this meeting, the following procedure for detailed study and evaluation was agreed upon:

1. The Soil Conservation Service will make field surveys of valley cross sections, investigate tentative dam sites, prepare input data sheets for computing water surface profiles (backwater curves), and depth-area inundation curves, furnish the Corps with water surface profiles, locations of floodwater retarding structures, and valley cross section data.

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2. The Corps will determine unit hydrographs or discharge distribution graphs at Harrison, delineate routing reaches in conjunction with Soil Conservation Service, and develop distribution graphs at ends of each reach, both for natural conditions and with the dams in place, and perform all flood routing necessary to coordinate the flows throughout the stream. In connection with this phase, the Soil Conservation Service will furnish Corps with spillway rating data and a joint selection of the sluice rates will be made to complete the hydrograph analysis. The Corps will make the frequency analysis of flows at all locations on a seasonal basis and will furnish Soil Conservation Service with all discharge data required to enter the area-overflow curves to determine the property flooded. The Corps will also prepare the necessary descriptive data and related charts for preparation of this phase of the report.

3. The Corps will develop, with Soil Conservation Service concurrence, general economic data and related charts for preparation of this phase of the report.

4. The Soil Conservation Service will develop economic data for the agricultural portion of the watershed; use peak discharges for various frequencies as determined by the Corps for both present and future to determine area inundated by depth increments for these conditions; determine rural benefits of Soil Conservation Service measures; determine costs of Soil Conservation Service structural measures; determine benefit-cost ratio of Soil Conservation Service structural program.

5. The Corps will develop cost of improvement for urban protection with and without Soil Conservation Service structures in place and determine, with Soil Conservation Service concurrence, benefits that would result from urban protection under both conditions.

6. The Corps and the Soil Conservation Service will jointly determine benefits and benefit-cost ratio of combined programs.

Following the May 6, 1961 flood which occurred after the joint study was in progress, the Corps of Engineers was authorized to study other plans by a resolution from the Public Works Committee, dated May 16, 1961. In addition, an Urban Renewal Program was originated to rehabilitate and improve levees, floodwalls, and conditions within the flood-plain of the city of Harrison.

Divided local interests caused separate reports, one a survey report by the Corps of Engineers and the other a work plan under Public Law 566, to be developed and submitted for approval proposing different solutions to the watershed problems. These reports were returned to the agencies by the Bureau of the Budget with instructions to develop one plan with unified local support.

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The local sponsors were apprised of this development and, after consideration, agreed upon a set of objectives for solving the watershed problems. These objectives and a request for action by the two cooperating agencies to develop a plan to meet the objectives was transmitted to the Soil Conservation Service and the Corps of Engineers.

These developments resulted in a meeting between the two agencies to determine the part which each agency would play in the restudy. It was agreed during this meeting that:

1. Work to be accomplished by each agency would be generally the same as agreed upon in the original cooperative study.

2. The Urban Renewal improvements would be considered as present conditions.

3. The Soil Conservation Service and the Corps of Engineers would jointly select from Urban Renewal data, cross sections to be used in the computation of stream flows through the city.

4. The Soil Conservation Service and the Corps of Engineers would jointly select the "n" values for the urban stream reach.

5. The Soil Conservation Service would adjust and replot cross-section data; prepare input data sheets for computation of hydraulic parameters, and furnish the Corps with elevation versus area and hydraulic radii curves for channel and overbank areas in the urban area.

6. The Corps of Engineers would perform all flood routing and compute water surface profiles for the urban reach.

7. The Corps of Engineers and the Soil Conservation Service would select the site for the water supply and flood control structure on the East Fork.

8. The Corps of Engineers would determine whether inclusion of water supply storage in the multiple-purpose site on the East Fork was practical and justified.

Both agencies agreed that the result of the general study should be completed and furnished to the local sponsors for appropriate comments prior to preparation of authorizing documents.

The sponsors reviewed the results of the general study and approved the presentation of the twenty-two dam system in a Public Law 566 work plan, providing reference to the modification of this plan by a multiple-purpose site being studied by the Corps of Engineers for inclusion in a survey report. It was felt that this method of presentation would provide protection for the watershed at an earlier time with the construction of the smaller single-purpose structures.

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The United States Forest Service made the following field investigations to determine forest conditions and treatment needs in the watershed: one hundred systematically selected sample plots were visited to gather data on the forest soil; conditions of the forest floor cover; the effect of fire, grazing, management, and logging practices on forest conditions; and the need for remedial forestry measures and practices. These data were supplemented by material from other surveys, consultations with other agencies, and discussions with forestry officials. Program recommendations were then developed to include only that amount of work that can be installed during the program installation period and only those measures and practices that contribute directly to flood prevention and soil stabilization.

Engineering

A base map of the watershed was prepared to show the watershed boundary, drainage pattern, system of roads, and other pertinent information.

Tentative locations for twenty-two floodwater retarding structures sites were selected by stereoscopic photo-study and field examination:

1. Topographic maps with 4-foot contour intervals were developed from engineering surveys of the pool area for each site. The May 7, 1961 storm resulted in an estimated runoff of 5.5 inches. The height of the dams and the size of the pools were determined by the storage volume needed to detain runoff ranging from 7.0 to 10.0 watershed inches to give the level of protection desired for the urban area. Additional sediment storage is provided in the floodwater retarding structures.

2. Structure data tables were developed to show the drainage area, storage capacity planned for floodwater detention, sediment storage, release rate of the principal spillway, emergency spillway capacity, area inundated by the pools and other pertinent data for each structure (table 3).

3. Floodwater retarding structure detention capacity volumes exceed the minimum requirements after allowance for a 50-C.S.M. maximum release rate, as outlined by Watershed Memorandum AK-302.

Hydraulic and Hydrologic

Engineering surveys were made of 96 stream channel and valley cross sections selected to represent adequately the stream hydraulics and the flood-plain area. Preliminary locations for 52 cross sections in the agricultural reaches were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected by field observation, after considering the needs of the economist and geologist. The channel sections

and part of the overbank area for the remaining 44 cross sections located in the city of Harrison, Arkansas, on Crooked Creek, Little Dry Jordan, and Dry Jordan tributaries were resurveyed in 1961 at locations determined by the Corps of Engineers during a 1949 survey of the urban area. All urban cross sections were adjusted to reflect the planned Urban Renewal channel improvement and levee system as a pre-project condition.

The following procedure and division of work for a joint hydrologic study and evaluation of proposed works of improvement was agreed 1/ upon by the Corps of Engineers and the Soil Conservation Service prior to the initiation of planning.

The Soil Conservation Service surveyed valley cross sections; surveyed upstream floodwater retarding structures, computed water surface profiles by Doubt's Method; computed depth-area inundation curves; developed stage-end area curves; developed principal and emergency spillway rating curves for floodwater retarding structures and made a joint selection of principal spillway release rates with the Corps. All other available basic data was interchanged between the agencies, as necessary.

The Corps of Engineers developed unit hydrographs and discharge distribution graphs at Harrison, distribution graphs both for present conditions and with the dams assumed in place at the twenty-two dam sites, at the end of designated routing reaches and for other intermediate areas. The Corps performed all flood routing necessary to coordinate the flows through the stream; developed the frequency analysis of flows at all locations on a seasonal basis and furnished discharge frequency data necessary to determine flooding under present and modified conditions. A total of 108 frequency arrays were developed for discharges ranging from where flooding begins to the Corps Standard Project Flood (13.5 inches of runoff in 48 hours) at 13 locations on Crooked Creek and the principal tributaries. The data indicates that flooding occurs on the average of three to four times per year under present conditions. The procedures used in connection with determination of flood frequencies are summarized in the following paragraph.

Generalized peak discharge-frequency data were developed using essentially all the stream gaging stations in north Arkansas and south Missouri. The frequency data are generalized on the basis of two principal factors which create peak discharges: (1) the volume of surface runoff which reflects the rainfall, soils, and ground cover, and (2) the distribution of surface runoff which is related to the topography, stream pattern, and shape of the hydrograph. Average unit hydrographs, all for a 2-hour rainfall excess for

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1/ A discussion of the agreed-upon document which enumerates the procedure for all phases of the joint study is included in the preceding section.

consistency were determined for 42 gaging stations with drainage areas ranging from 0.6 to 2,038 square miles. Empirical relationships between the peak discharge of the unit graphs and the characteristics of the respective watersheds were developed, plotted separately for areas less and greater than 100 square miles, and used later for developing unit hydrographs for Upper Crooked Creek.

The average annual volume of surface runoff was computed for the 10-year period, 1950 through 1959, for all gaging stations in the subject area where flows were unregulated.

Annual peak discharge frequency curves were developed for each of the 28 stations in the area having records of ten years or more. Frequency curves were also developed for each month of the year in order to apply the data on a seasonal basis for evaluation of the agricultural reaches.

A coordinated system of representative discharge or distribution hydrographs was required at dam sites, at the ends of routing reaches, at other intermediate points, and at Harrison. Unit hydrographs for a 2-hour rainfall excess were first determined empirically at the various locations, using the basic data developed from the gages previously mentioned and the subwatershed characteristics at the locations outlined. These unit hydrographs were then routed downstream through the various reaches to Harrison to correlate each distribution graph with the other in the network. The relationships between storage and discharge in the reaches were determined from the flood-wave travel and were assumed to be linear in accordance with the principles of the unit hydrograph. The coefficient method of routing was used with storage modification factors "x" of 0.3 to 0.5 assumed in accordance with stream characteristics.

The present hydrologic condition of the watershed, excluding woodland areas mapped by the United States Forest Service, was determined by use of existing soil surveys, work unit land use and treatment records, and other pertinent information contributed by local area and work unit conservationists and soil scientists. Consideration was given to other factors such as geology, cropping practices, topography, soil, cover, and climate.

The United States Forest Service provided hydrologic conditions and runoff curve numbers for the woodland areas, both present and future.

The future hydrologic condition was developed from data furnished by the work unit relative to expected changes in land use resulting from an accelerated land treatment program during the project installation period. Present and future soil cover complex curve numbers of 74 and 72, respectively, were computed from the above data to determine rainfall-runoff relationships used primarily in the evaluation as a basis for design of floodwater retarding structures.

Stage-discharge-area inundation curves were developed for each portion of the valley represented by a cross section.

Determination was made of area inundated under conditions which would exist due to:

a. Present condition of the watershed

b. Effect of land treatment measures and

c. Effect of land treatment and floodwater retarding structures

Freeboard inflow hydrographs, computed using antecedent moisture condition II and future runoff curve number 72 were used to proportion structure emergency spillways since detention storage exceeded the emergency spillway hydrograph volumes except for sites 9, 15, and 16. Freeboard hydrographs were developed by the distribution graph method according to Watershed Memorandum AK-301. Floodwater retarding structure classifications are as follows:

1. Class "c" structures are sites 12, 13, 14, 15, 16, 17, and 18

2. Class "b" structures approaching class "c" structures are sites 2, 4, 10, 11, 20, 21, and 22

3. Class "b" structures are sites 1, 3, 5, 6, 7, 8, 9, and 19.

Precipitation amounts used in determining the 6-hour freeboard hydrograph volumes slightly exceed the ES-1020 chart values for the various structure classifications.

Emergency spillway designs for the structures were obtained by graphical flood-routing method number 2, outlined in National Engineering Handbook, Section 5, page 5.8-12. Minimum design criteria for all structures exceeded both with respect to volume of detention storage and runoff amounts used to design the emergency spillways and top of dam elevations.

Detention storage volume in 21 of the 22 structures exceeds the minimum class "c" requirements of Watershed Memorandum AK-302, after allowance for a 50-C.S.M. release rate. Physical potential of the sites and location in the watershed were considered in establishing detention storage volume. Other major factors considered in establishing storage volumes and in

proportioning dams and spillways are: (1) necessity of providing a high level of protection for the Harrison urban area, and (2) proper modification of the large storms.

The runoff from a 48-hour rainfall of 16.8 inches under present condition is estimated to be 13.5 inches (Corps Standard Project Flood at Harrison). This storm results in an estimated peak discharge of 70,000 c.f.s. at cross section 23 on Crooked Creek at the mouth of Dry Jordan tributary (reach 4). After installation of the measures proposed in this plan, the modified peak discharge at the same point for this storm would be 26,700 c.f.s., a reduction of 62 percent.

Storm of Record - Rainfall for the high intensity storm of May 7, 1961 varied from approximately 4.5 to 6.0 inches, according to measurements from 22 rain gages and six bucket surveys in and near the watershed. The average rainfall for the watershed was about 5.9 inches, 5.0 inches of which occurred in a 2-hour period. The estimated surface runoff was 5.5 inches. The 6-day antecedent rainfall at Harrison gage was 5.6 inches, resulting in soil moisture near field capacity when the storm occurred. The intense thunderstorm which was associated with the passage of a cold front built up to an altitude of 48,000 feet near the southwest extremity of the watershed according to local radar observers and finally moved across the watershed in a northeasterly direction. Several small tornadoes occurred in a surrounding two-county area.

The following additional factors apparently contributed to the extremely high peak flow for the storm: (1) non-uniform distribution of rainfall over the basin with respect to area and time of occurrence, (2) the storm centered in the upper extremity of the watershed for about one to one and one-half hours, and then moved down the basin in the general direction of the stream flow with a timing that appeared to accentuate the peak flow at Harrison.

The May 7, 1961 storm resulted in an estimated peak discharge of 54,000 c.f.s. at cross section 23 on Crooked Creek at the mouth of Dry Jordan tributary (reach 4). After installation and full functioning of the measures proposed in this plan, the modified peak discharge at the same point for this storm would be 21,600 c.f.s., a reduction of 57 percent. The twenty-two proposed structures would store the entire estimated 5.5 inches of runoff from this storm from the controlled area of 48.6 square miles with an average use of only 65 percent of the detention storage capacity.

Data collected on the flood served as an aid in defining stage-discharge, stage-area inundated, and stage-damage relationships at Harrison and in the agricultural reaches evaluated.

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Geologic

The watershed lies principally on the Springfield plateau of the Ozark Mountain region of the Interior Highland Physiographic Province. However, Gaither Mountain which forms the southwestern watershed boundary and Boat and Sulphur Mountains on the south and southeastern boundary are northern extremities of the Boston Mountains. Elevations on these mountains range from 2,100 feet to 2,220 feet above mean sea level. The elevation of the Springfield plateau ranges from 1,000 feet to 1,200 feet above mean sea level. Downstream from the city of Harrison, Arkansas, Crooked Creek has cut through the Eureka Springs escarpment which separates the higher Springfield plateau and the lower Salem plateau. In this reach of the stream, rocks from the uppermost Lower Ordovician Age and Powell limestone to the Boone formation of Lower Mississippian Age are exposed. The part of the Springfield plateau within the watershed has been formed from limestone and cherty limestone of the Boone formation. The rocks of the Boston Mountain area range in age to the Lower Pennsylvanian Atoka formation.

The regional dip of the geologic formations is low in a generally southerly direction. There is one major fault within the watershed, the Crooked Creek fault. This fault is located in the extreme northeast part of the watershed and does not affect any of the planned structures. The fault is unusual in this area in that the downthrown side is north of its trace. Probable displacement is about 50 feet. There are numerous small folds in locations where the thin Batesville sandstone overlies the Boone formation. This phenomenon could be the result of slumping caused by caverns and solution channels in the Boone limestone.

A preliminary geologic investigation was made on each of the twenty-two planned structures. These investigations included studies of lithology, stratigraphy, channel banks, abutments, groundwater, and possible borrow areas. The material of the borrow areas was classified in the field in accordance with the Unified Soil Classification System. These investigations were conducted with the use of a portable power auger and a portable seismograph. These investigations indicated that the following conditions would exist at the structure sites within the watershed.

Foundations - The foundation of all planned structures, with the exception of site number 11, will be the Boone formation. The foundation of site number 11 will be the Batesville sandstone. The sandstone should offer no geologic problems as a foundation; however, the Boone formation may offer foundation problems. This is due, in part, to the irregular weathering and solution features found associated with this formation. The Boone formation is made up largely of limestone, cherty limestone, and in places chert, itself. The limestone is generally gray, compact, finely to coarsely crystalline, massive bedded with a well developed system of joints. The limestone of the Boone formation is nearly pure calcium carbonate and, therefore, is easily dissolved by circulating groundwater.

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It is possible that grouting may be required on a limited number of sites; however, this cannot be determined until detailed site investigations are made. The possibility of the need for grouting was recognized and liberal allowances were included in the estimate of construction costs to provide for this contingency.

As determined with the seismograph, depth to the unweathered Boone varies considerably. Overlying the unweathered Boone is a horizon of weathered material of varying thickness. This horizon consists of chert, flags, cobbles, and gravels in a red plastic clay matrix. In the valleys, generally, there is a horizon of chert, cobbles, and gravels in a silty sand or clayey sand matrix. This horizon has a maximum thickness of six feet. Overlying this is a horizon of fines that vary considerably in the clay, silt, and sand fraction. The thickness of this top horizon averages about six feet.

Emergency Spillway - There will be a small amount of rock excavation on the twenty-two planned structures. Most of the emergency spillways will be in the deeply weathered material. The chert in the clay material should offer no extreme difficulty of removal.

Borrow Areas - Borrow may be obtained in the sediment pools of all sites; however, additional borrow material will be needed for sites 11, 13, 17, and 18. The additional borrow for these sites may be obtained on the abutments and in the flood pools. Most of the borrow material was classified in the field as CL and GC; however, some of the material was classified as SM and some SC in the Unified Soil Classification System.

Preliminary Recommendations - Detailed subsurface investigations will be made on all sites prior to design and construction. The use of a bulldozer or backhoe to dig test pits and trenches should be quite useful to the detailed geologic investigations on each of the twenty-two sites.

Trench drains with a perforated pipe may be required on all structures to intercept any water seeping along the bedding planes and joints beneath the structures and to lower the phreatic line within the structure. It is possible that clearing the vegetation and roots and backfilling the channel will help prevent excessive loss of water. The borrow will be located far enough from the centerline of the embankment to prevent the introduction of additional seepage into the foundation.

There are a number of sink holes observed along the divide of the subwatershed; however, none were seen in the sediment or flood pool areas. A number of streams are fed by perennial springs.

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Sediment

A field survey of the sedimentation problems in the watershed was made in accordance with methods prescribed in Watershed Memorandum AK-11, "Sediment Investigations in Work Plan Development," Soil Conservation Service, dated August 21, 1959. Field studies included reconnaissance surveys of geology and physiography, studies of overbank deposits, streambank erosion, and the characteristics of valleys and channels on most of the valley cross sections. In the preparation of the work plan, tabular summaries of these findings were prepared as a basis of calculation of monetary damages by the economist.

The sediment derived from sheet erosion was calculated by use of a formula shown in "A Method of Estimating the Rate of Soil Loss by Sheet Erosion from Individual Fields or Farms Under Various Types of Land Treatment," Soil Conservation Service, Fort Worth, Texas, December 1953. The formula is based on data obtained by watershed surveys and includes the following:

1. Soil unit in acres, by slope in percent, slope length in feet, and present land use (cultivated, pasture, and woodland).

2. Average farming practices (such as terracing, contour cultivation, small grain, row crops, etc.).

3. Cover condition classes or pasture and woodland.

4. Past history of land use.

5. Maximum 30-minute rainfall intensity to be expected once in two years.

Investigations were made in the drainage area above three of the planned structures. The basic erosion rates for each land use, as determined from the detailed investigation of three sites, were expanded to the remaining sites on the basis of land use conditions found during the reconnaissance of the nineteen remaining sites.

The allocation of sediment was made in accordance with Watershed Memorandum AK-10, Soil Conservation Service, January 1959.

Economic

On the basis of procedures developed with the Corps of Engineers, the Soil Conservation Service developed the rural economic data and the Corps of Engineers developed the economic data for the urban area.

Items from the cooperative agreement between the two agencies are quoted below:

> "Item 3: Corps will develop, with Soil Conservation Service concurrence, general economic data for urban area, including construction of stage or flow damage curve.

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"Item 4: Soil Conservation Service will develop economic data for agricultural portion of the watershed, use peak discharges for various frequencies as determined by Corps for both present and future to determine area inundated by depth increments for these conditions, determine benefits of Soil Conservation Service measures; determine cost of structural measures; determine benefit-cost ratio of Soil Conservation Service structural program."

The Corps of Engineers made flood damage surveys in Harrison during and immediately following some of the larger floods, including the May 1961 flood. A determination was made of the stage at which damage begins as well as the amount of loss incurred from the experienced floods. Estimates of damage that would occur from the Standard Project Flood were also made. From these data, a stage-damage curve was developed to cover the entire range of damage-producing floods. Having determined the probable frequency of floods of various magnitudes and the amount of damages to be expected from these floods, a damage-frequency curve was developed and used to determine the estimated average annual flood losses. This procedure was used for "without project" and "with project" conditions. The frequency method of analysis was used to determine urban benefits. For the purpose of this evaluation, the average annual flood damages under existing conditions are considered to reflect average future conditions "without project." No enhancement or changed land use benefits were claimed.

To carry out the Soil Conservation Service responsibility in this cooperative study, the frequency method of appraisal was used. The following basic data tables were developed in the appraisal of benefits and costs:

1. Damageable value per acre of flood plain

2. Crop damage rates by seasons and by depth of flooding

3. Discharge frequency - damage data by seasons

Agricultural damage estimates were based on damage schedules obtained in the field, covering approximately 48 percent of the flood plain. It was found that there was little difference in land use and damageable values throughout the flood plain but, for convenience in stream reach routing, the flood plain was divided into eight reaches, exclusive of the urban area of Harrison. Individual appraisals of damages and benefits were made on each reach of the flood plain. The monetary value of damage in the flood plain was determined on the basis of 1960 prices and converted to long-term prices for benefit-cost analysis.

Damage rates were determined for both season and depth of flooding. The damage to flood-plain lands by sediment and scour was determined on the basis of reduced productivity and increased cost of production using

Watershed Memorandum AK-101. Areas included in the pools to be created by the structures were excluded from damage estimates.

Crop, pasture, and other agricultural damages were calculated for significant flood stages and seasons of the year to establish discharge frequency and agricultural damage relationships. Average annual damages were calculated by using the damage frequency method of analysis. The average annual crop and pasture damages were then adjusted downward to reflect effects of recurrent flooding on total damages in a single crop season. Adjustment factors approximate those which were developed in comparable watershed for which more precise data were available.

Determination of Benefits

Floodwater damages were calculated under natural conditions and under conditions which will prevail after the installation of each group of measures included in the work plan. The difference between the average annual damage at the time of initiation of each group of measures and those after their installation constitutes the benefit brought about by that group through reduction of damages. No benefits were estimated for the pool areas of the structures.

Benefits from restoration of productivity to flood-plain lands were classed as a damage reduction benefit in table 5. Consideration was given to future damage to the increased production and the added damage was deducted. All benefits from restoration are net benefits remaining after production costs have been deducted and adjustment made for a three-year lag for installation. A three-year period was used for lag since there were no conversions of land and, in effect, only a change of rotations was necessary to obtain the increased production.

The reduction in sediment production rates by land treatment, the area behind the structures, the estimated trap efficiency of the structures, and the reduction in area flooded were considered in determining the reduction of damages from overbank deposition. Reduction in scour damages was determined by assigning appropriate scour power factors to the acres flooded by different depth increments. These weighted figures, as they compared to conditions without a project, gave the percent of present scour damage that would remain after project installation. Their difference was considered a benefit.

Incidental Recreation Benefits

Recreation benefits are expected to accrue incidentally to the installation of the floodwater retarding structures included in this plan. Flood prevention was the only purpose considered in the location and design of the structures; consequently, no additional project costs will be necessary to obtain recreation benefits from the sediment pools of the structures. It

4-19475 11-64

is estimated that the proposed floodwater retarding structures will have a potential surface area of 261 acres for recreation use. All of the structures are readily accessible.

The number of visitors-days' use is estimated to be 12,800, annually. In estimating the number of visitor-days, consideration was given to public access, surface area, population, and alternate recreation facilities. To account for the competition for recreation which exists because of nearby Table Rock, Bull Shoals, and Norfork reservoirs, the expected number of visitors was reduced by 20 percent. The population within a 50-mile radius of the watershed is approximately 64,000 persons (1960 census).

To insure a conservative estimate of the value of recreation activity, a gross value of 50 cents per visitor day was used in the economic evaluation. From the total gross benefit was deducted the cost necessary to make the area attractive. These included the cost of sanitary facilities, tables, changing stalls, and entrance signs. Costs for operation and maintenance, replacement, and liability insurance were deducted also. The net value of recreation benefits was discounted five years to allow a buildup to their full level. Net benefits were further discounted to account for the diminishing desirability of the structures because of the accumulated sediment. It was assumed that recreation benefits would cease by the eightieth year.

In analyzing redevelopment benefits, consideration was given to the proportion of the construction costs that are being expended for labor in similar type construction in Arkansas. Recent construction experience indicates that labor costs range from 6 to 8 percent of contract costs. However, due to the relative amount of skilled to unskilled labor required in construction, it was considered that 5 percent of the costs would be appropriate in this case. Redevelopment benefits resulting from the operation and maintenance of structural measures were estimated to be 50 percent of total cost during the first twenty years. Benefits from operation and maintenance were treated as a decreasing annuity. Appropriate discounting factors were used to bring these benefits to present worth.

In calculating secondary benefits, 10 percent of the value of goods induced by the project and stemming from the project were claimed as secondary benefits. Indirect and redevelopment benefits were excluded in calculating secondary benefits.

Project Costs

Project installation costs were amortized for 100 years at 3.125 percent interest. Operation and maintenance costs were converted to 1957 long-term price levels, as projected by ERS, September 1957.

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Engineering contingency costs were estimated to be 10 percent of the engineer's estimate. All engineering and other engineering services costs were computed as set forth in Watershed Memorandum AK-13.

The costs of land, easements, and rights-of-way, necessary for the installation of the proposed measures were determined by individual appraisal in cooperation with local representatives. Consideration was given to the value and size of the unit where each structure is located.

The annual net loss of production and associated secondary losses, based on long-term prices, within the floodwater retarding structures, were calculated and this value compared with the amortized cost of appraised land values. In this determination, it was assumed that, under project conditions, land within the sediment pools would have no productive value and land in the detention pools would be converted to grassland. The amortized cost of land exceeded the net loss in production; consequently, no other economic costs will be incurred.

4-19475 11-64

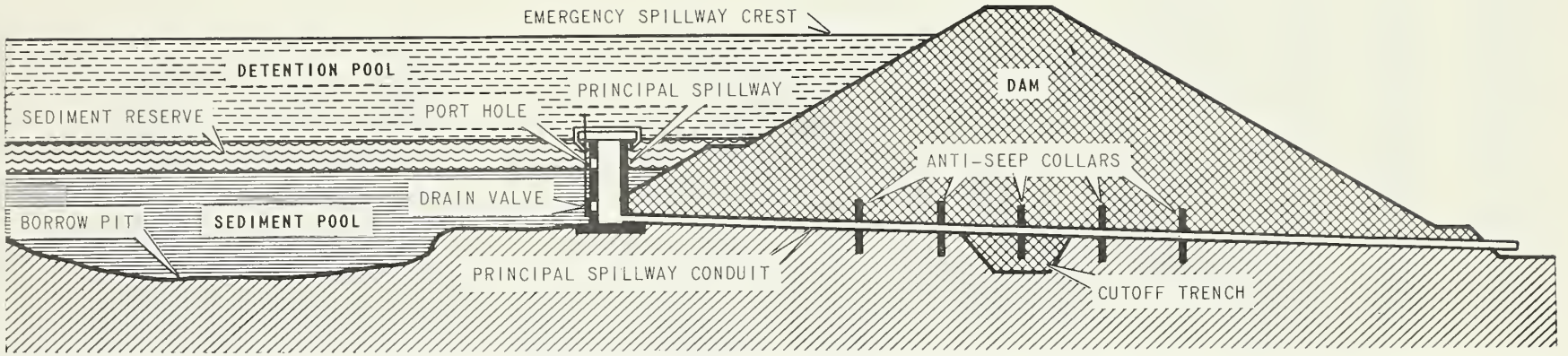


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Revised 10-31-60 4-L-10,071

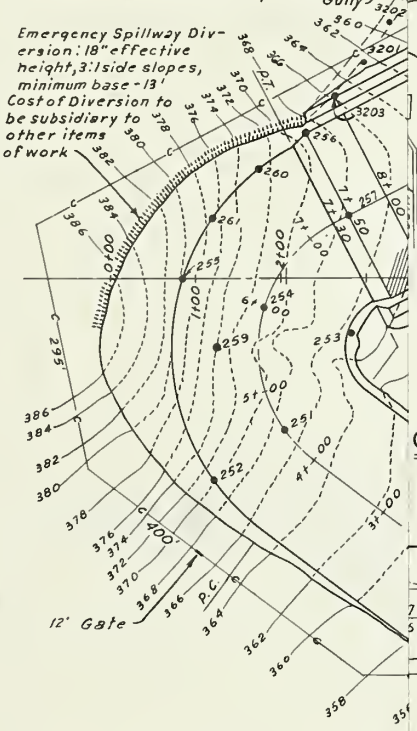
A minimum of 6" of topsoil to be placed in spillway and on all "compacted fill areas" See the specifications.

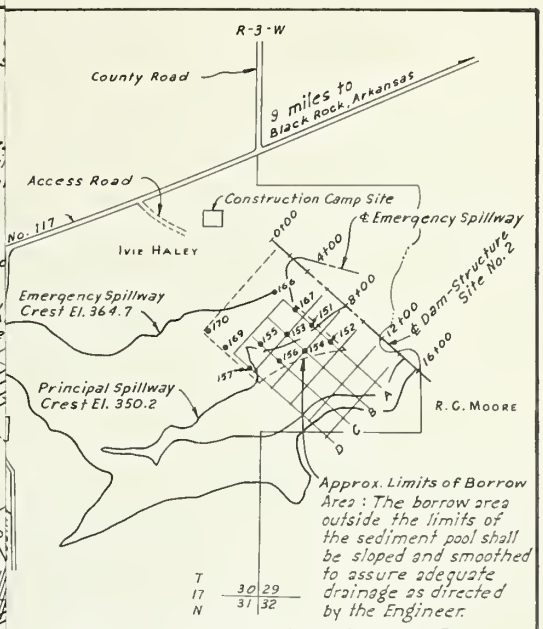
Stream Channel within embankment area to be cleared of objectionable material in accordance with "Stream Channel clearing" out" of the specifications.

Spur Diversions: Approx. 100 ft. long to be constructed at terrace intervals to divert runoff water away from Emergency Spillway Diversion from approx. Sta. 1+50 to Sta. 7+50. Not a pay item.

Emergency Spillway Diversion: 18" effective height, 3:1 side slopes, minimum base - 13'

Cost of Diversion to be subsidiary to other items of work



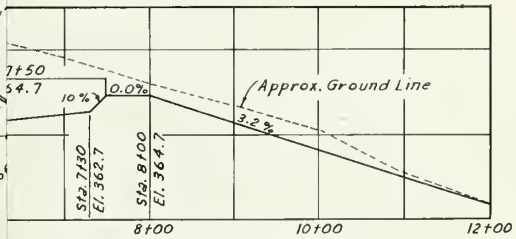


Structure Site No. 2 located in Section 29, T-17-N, R-3-W approx. 1 mile south-west of Denton Lawrence County, Arkansas.

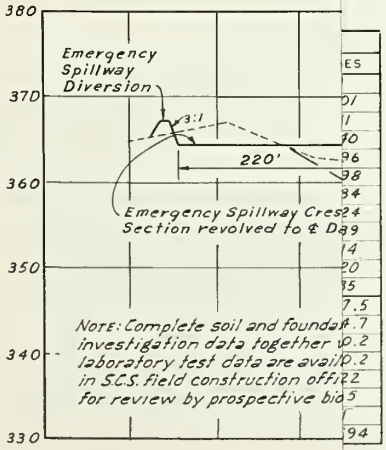
VICINITY MAP AND GENERAL PLAN OF RESERVOIR

0 697 1394 1891 2788

SCALE IN FEET



OF EMERGENCY SPILLWAY

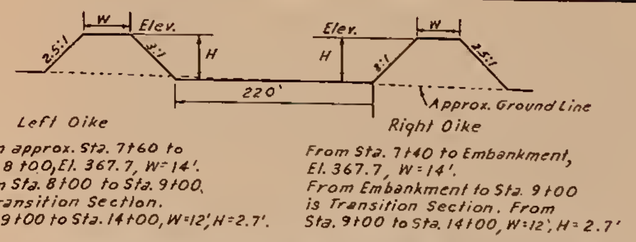


Note: Complete soil and foundation investigation data together with laboratory test data are available in S.C.S. field construction office for review by prospective bidders.

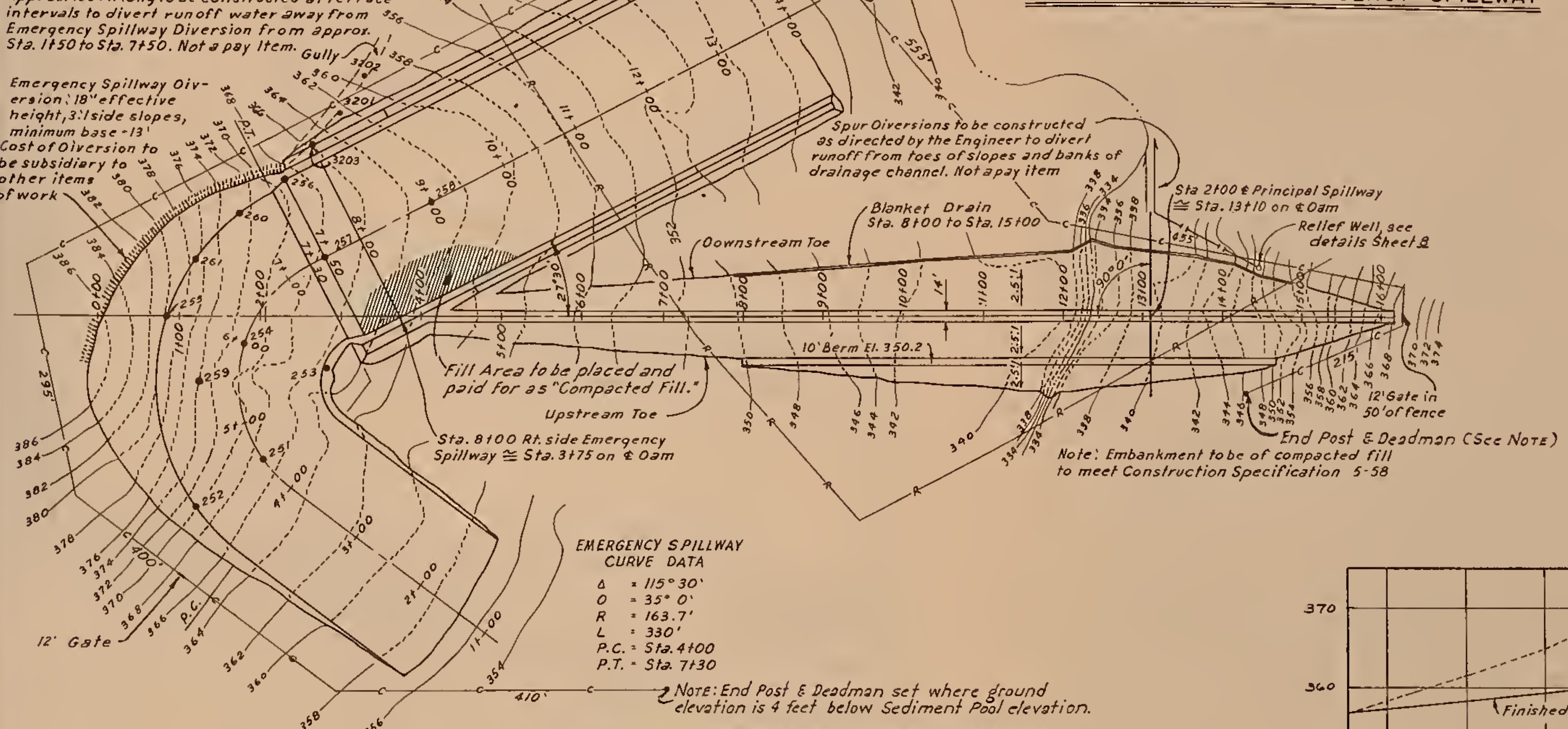
Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed W. J. B., E. J. E. R.	Date 3-60	Approved by ... HEAD ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS	
Drawn W. J. B. & M. G. C.	3-60	STATE CONSERVATIONIST ENGINEER S. C. S. LITTLE ROCK, ARKANSAS	
Traced M. G. C.	4-60	Sheet No. 2 of 8	Drawing No. 4-E-14,512
Checked C. F. C. & W. J. B.	5-60		


Elev.
W
H
2.5:1
3:1
220'
Approx. Ground Line
Left Dike
Right Dike
From approx. Sta. 7+60 to Sta. 8+00, El. 367.7, W=14'. From Sta. 8+00 to Sta. 9+00, is Transition Section. Sta. 9+00 to Sta. 14+00, W=12', H=2.7'.
From Sta. 7+40 to Embankment, El. 367.7, W=14'. From Embankment to Sta. 9+00 is Transition Section. From Sta. 9+00 to Sta. 14+00, W=12', H=2.7'

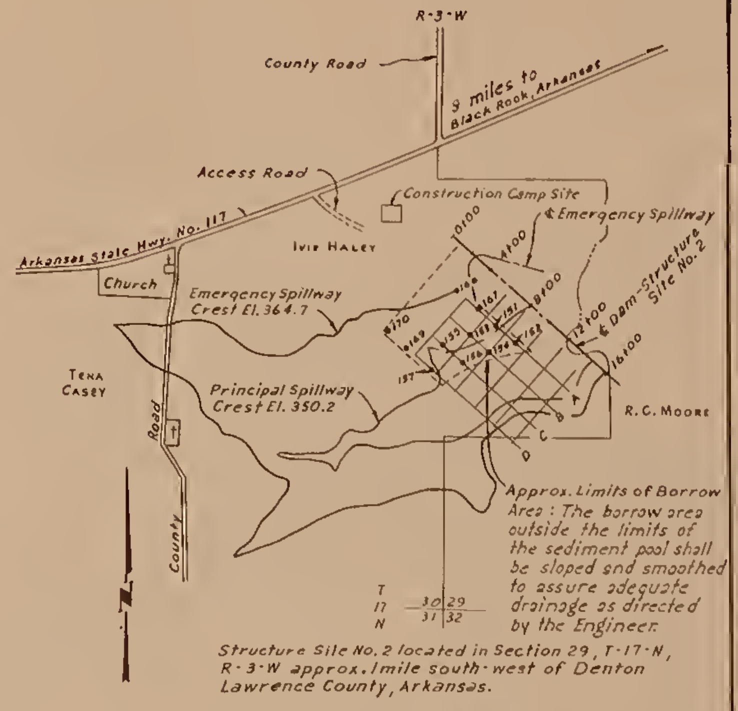
TYPICAL SECTION EMERGENCY SPILLWAY


A minimum of 6" of topsoil to be placed in emergency spillway and on all "compacted fill areas." See the specifications.
Stream Channel within embankment area to be cleared of objectionable material in accordance with "Stream Channel clean-out" of the specifications.
Spur Diversions: Approx. 100 ft. long to be constructed at terrace intervals to divert runoff water away from Emergency Spillway Diversion from approx. Sta. 1+50 to Sta. 7+50. Not a pay Item.
Gully
Emergency Spillway Diversion: 18" effective height, 3:1 side slopes, minimum base -13'
Cost of Diversion to be subsidiary to other items of work
Spur Diversions to be constructed as directed by the Engineer to divert runoff from toes of slopes and banks of drainage channel. Not a pay item
Blanket Drain Sta. 8+00 to Sta. 15+00
Downstream Toe
Sta 2+00 ¢ Principal Spillway ≅ Sta. 13+10 on ¢ Dam
Relief Well, see details Sheet 8
10' Berm El. 350.2
Fill Area to be placed and paid for as "Compacted Fill."
Upstream Toe
12' Gate in 50' of fence
End Post & Deadman (See Note)
Sta. 8+00 Rt. side Emergency Spillway ≅ Sta. 3+75 on ¢ Dam
Note: Embankment to be of compacted fill to meet Construction Specification 5-58
12' Gate
410'
EMERGENCY SPILLWAY CURVE DATA
Δ = 115° 30'
D = 35° 0'
R = 163.7'
L = 330'
P.C. = Sta. 4+00
P.T. = Sta. 7+30
Note: End Post & Deadman set where ground elevation is 4 feet below Sediment Pool elevation.

PLAN OF EMBANKMENT AND SPILLWAYS

0 697 1394 1891 2788 3485

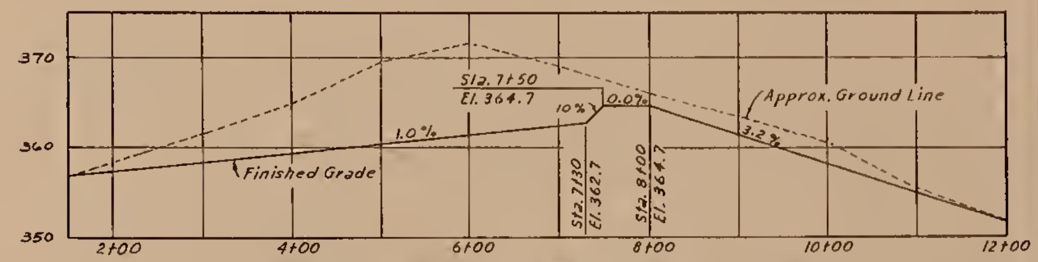
SCALE IN FEET


R-3-W
County Road
9 miles to Black Rock, Arkansas
Access Road
Construction Camp Site
¢ Emergency Spillway
Arkansas State Hwy. No. 117
Ivie Haley
Church
Emergency Spillway Crest El. 364.7
Dam Structure Site No. 2
Tena Casey
Principal Spillway Crest El. 350.2
R. C. Moore
County Road
Approx. Limits of Borrow Area: The borrow area outside the limits of the sediment pool shall be sloped and smoothed to assure adequate drainage as directed by the Engineer.
Structure Site No. 2 located in Section 29, T-17-N, R-3-W approx. 1 mile south-west of Denton Lawrence County, Arkansas.

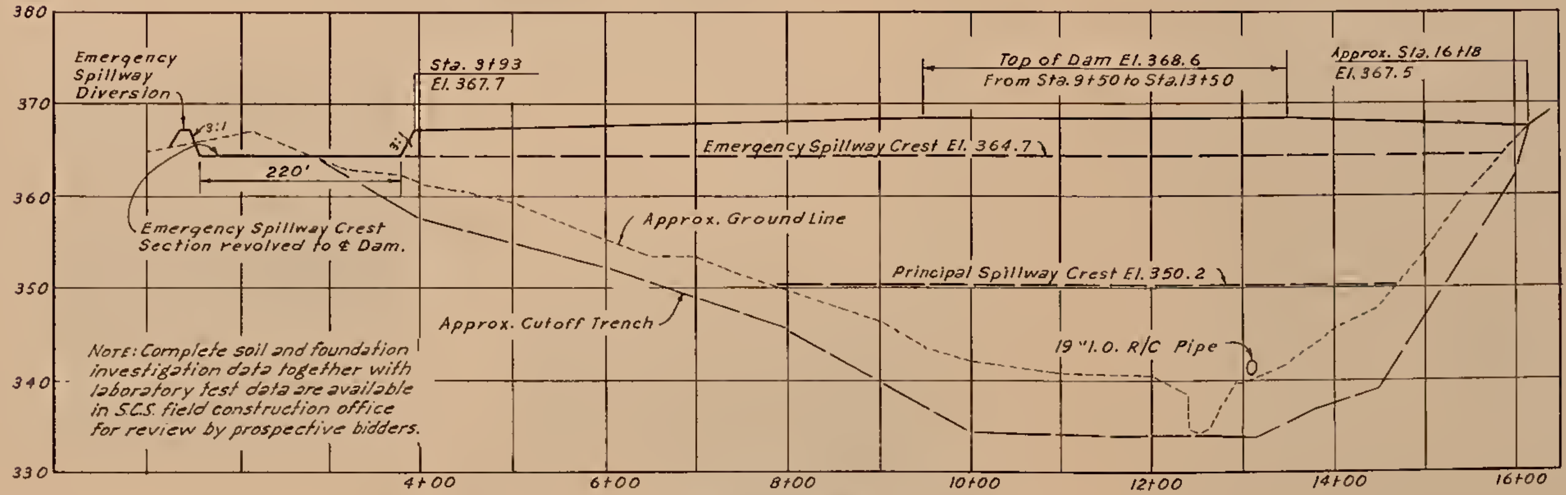
VICINITY MAP AND GENERAL PLAN OF RESERVOIR

0 697 1394 1891 2788

SCALE IN FEET



PROFILE ON ¢ OF EMERGENCY SPILLWAY


380
370
360
350
340
330
Emergency Spillway Diversion
Sta. 3+93
El. 367.7
Top of Dam El. 368.6
From Sta. 9+50 to Sta. 13+50
Approx. Sta. 16+18
El. 367.5
220'
Emergency Spillway Crest El. 364.7
Emergency Spillway Crest Section revolved to ¢ Dam.
Approx. Ground Line
Principal Spillway Crest El. 350.2
Approx. Cutoff Trench
19" I.D. R/C Pipe
Note: Complete soil and foundation investigation data together with laboratory test data are available in SCS field construction office for review by prospective bidders.
4+00
6+00
8+00
10+00
12+00
14+00
16+00

PROFILE ON ¢ OF DAM

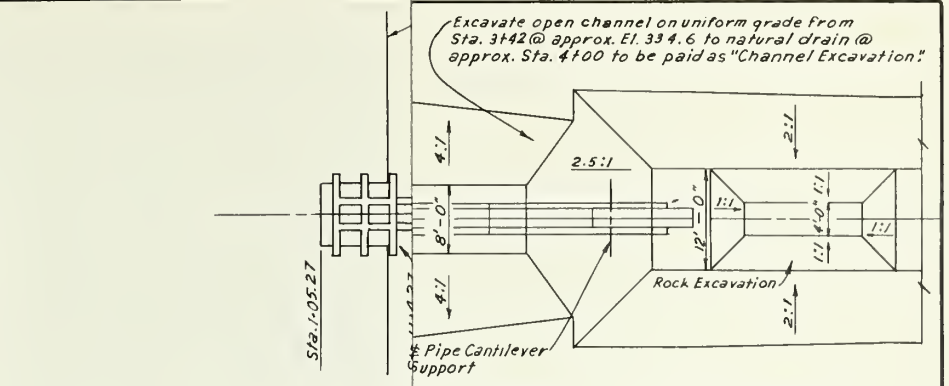
Elevation	Surface Acres	Storage	
		Acre Feet	Inches
335.0	0	0	0
338.0	1.1	0.8	0.01
342.0	4.8	12.6	0.11
346.0	12.5	47.2	0.40
350.0	21.0	114.2	0.96
350.2	21.6	119.0	0.98
354.0	30.8	217.8	1.84
358.0	52.4	384.2	3.24
362.0	74.6	638.2	5.39
364.7	86.0	846.0	7.14
366.0	91.9	971.2	8.20
368.6	101.2	1225.0	10.35

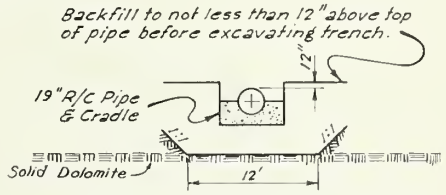
Top of Dam (Effective) Elev.	367.5
Emergency Spillway Crest Elev.	364.7
Principal Spillway Crest Elev.	350.2
Sediment Pool Elev.	350.2
Drainage Area, Acres	1422
Sediment Storage, Acre Feet	135
Floodwater Storage, Acre Feet	711
Max Emergency Spillway Cap., c.f.s	3694

Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

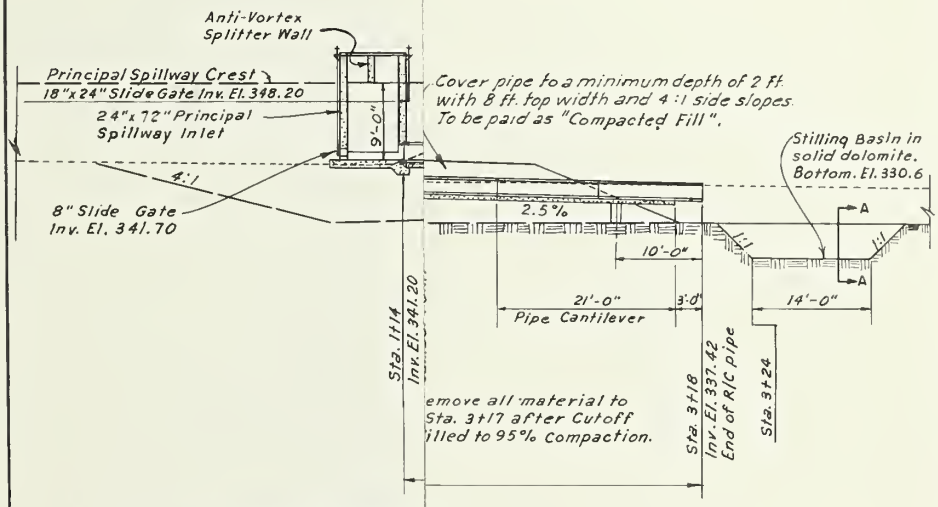
Designed W. J. B. & J. E. R.	3-60	
Drawn W. J. B. & M. G. C.	3-60	
Traced M. G. C.	4-60	
Checked C. F. C. & W. J. B.	5-60	Sheet No. 2 of 8 · Drawing No. 4-E-14,512





Excavation to be paid as "Cutoff Trench Excavation." Backfill prior to excavating pipe trench to be paid as "Compacted Fill"

TYPICAL FOUNDATION EXCAVATION



REQUIRED PLACEME		
EMBANKMENT SECTION		SOURCE OF
Sec No.	Description	Location
1	Any except Downstream Toe	Borrow - Zone Emergency Spill
1	Outer Sections, except Downstream Toe	Emergency Spi Borrow - Zone Cutoff Trench F.
2	Downstream Toe Drain Sta. 8+00 to Sta. 15+00	Stream Chann Downstream

presented
mple No. 1398

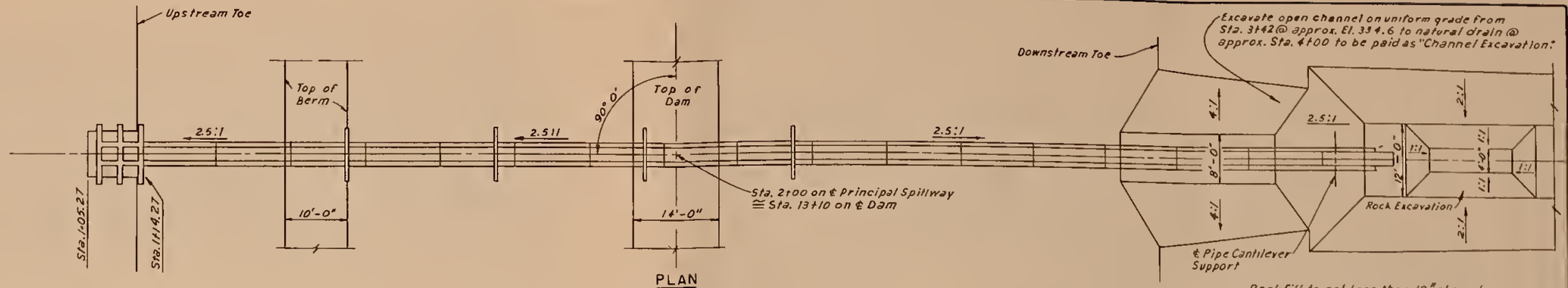
Note! For delineation of Borrow Zone

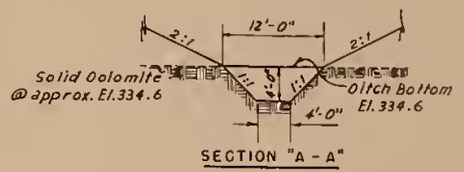
Zoning Note: "If the material being pla
amounts differing from the percentage
density and moisture requirement show

Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

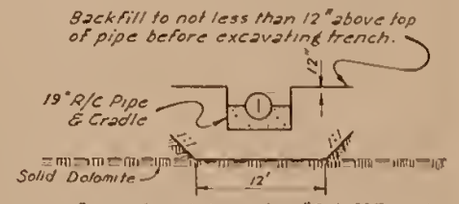
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed W.J.B. & J.E.R.	3-60	Approved by HEAD ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS
Drawn J.E.R. & M.G.C.	3-60	STATE CONSERVATION ENGINEER S.C.S. E.D.B.
Traced M.G.C.	4-60	LITTLE ROCK, ARKANSAS
Checked C.F.C. & W.J.B.	5-60	Sheet No. 3 of 8 — Drawing No. 4-E-14,512



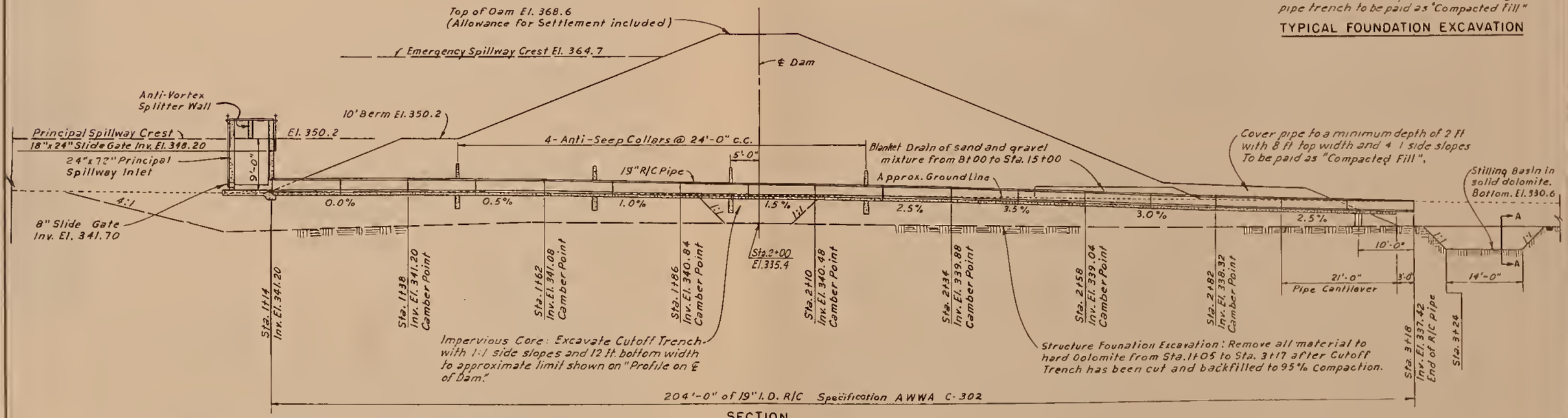


STILLING BASIN



Excavation to be paid as "Cutoff Trench Excavation." Backfill prior to excavating pipe trench to be paid as "Compacted Fill"

TYPICAL FOUNDATION EXCAVATION



SECTION

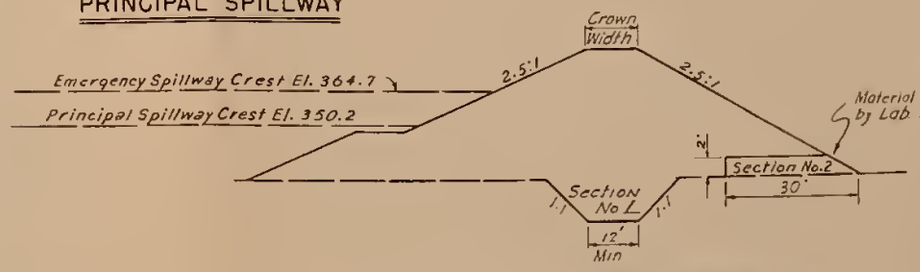
PRINCIPAL SPILLWAY

REQUIRED PLACEMENT OF EXCAVATED MATERIALS										
EMBANKMENT SECTION		SOURCE OF FILL MATERIAL			LAB TEST	COMPACTION REQUIREMENTS				Lab. Curve
Sec No.	Description	Location	Ave. Depth Feet		Standard	Min. Dry Density	Moisture Range Percent			
			From	To	Max Dry Den	Opt'm Moist	Lbs Per Cu Ft	From	To	No
1	Any except Downstream Toe	Borrow - Zone A	2'	12'	117.5	12.5	111.5	12.0	Up	1
		Emergency Spillway	2'	8'	108.0	18.5	102.5	18.0	"	5
1	Outer Sections, except Downstream Toe	Emergency Spillway	3'	15'	117.5	12.0	111.5	11.0	"	4
		Borrow - Zone B	2'	6'	121.5	10.0	115.5	9.0	"	2
		Cutoff Trench Excavation	2'	6'	118.0	12.0	112.0	11.0	"	3
2	Downstream Toe Drain Sta. 8+00 to 6ta. 15+00	Stream Channel-300' to 500' Downstream								

Note! For delineation of Borrow Zones See Geologic Investigation Sheets.

Zoning Note: "If the material being placed in the fill contains ¼ inch or larger material in amounts differing from the percentages found in the laboratory sample, the minimum dry density and moisture requirement shown above will be corrected for this variation.

ZONED EMBANKMENT DATA



TYPICAL SECTION - ZONED EMBANKMENT

Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed W.J.B. & J.E.R.	3-60	Approved by	
Drawn J.E.R. & M.G.C.	3-60		E.D.B.
Traced M.G.C.	4-60		
Checked C.F.C. & W.J.B.	5-60	Sheet No. 3 of 8	Drawing No. 4-E-14,512

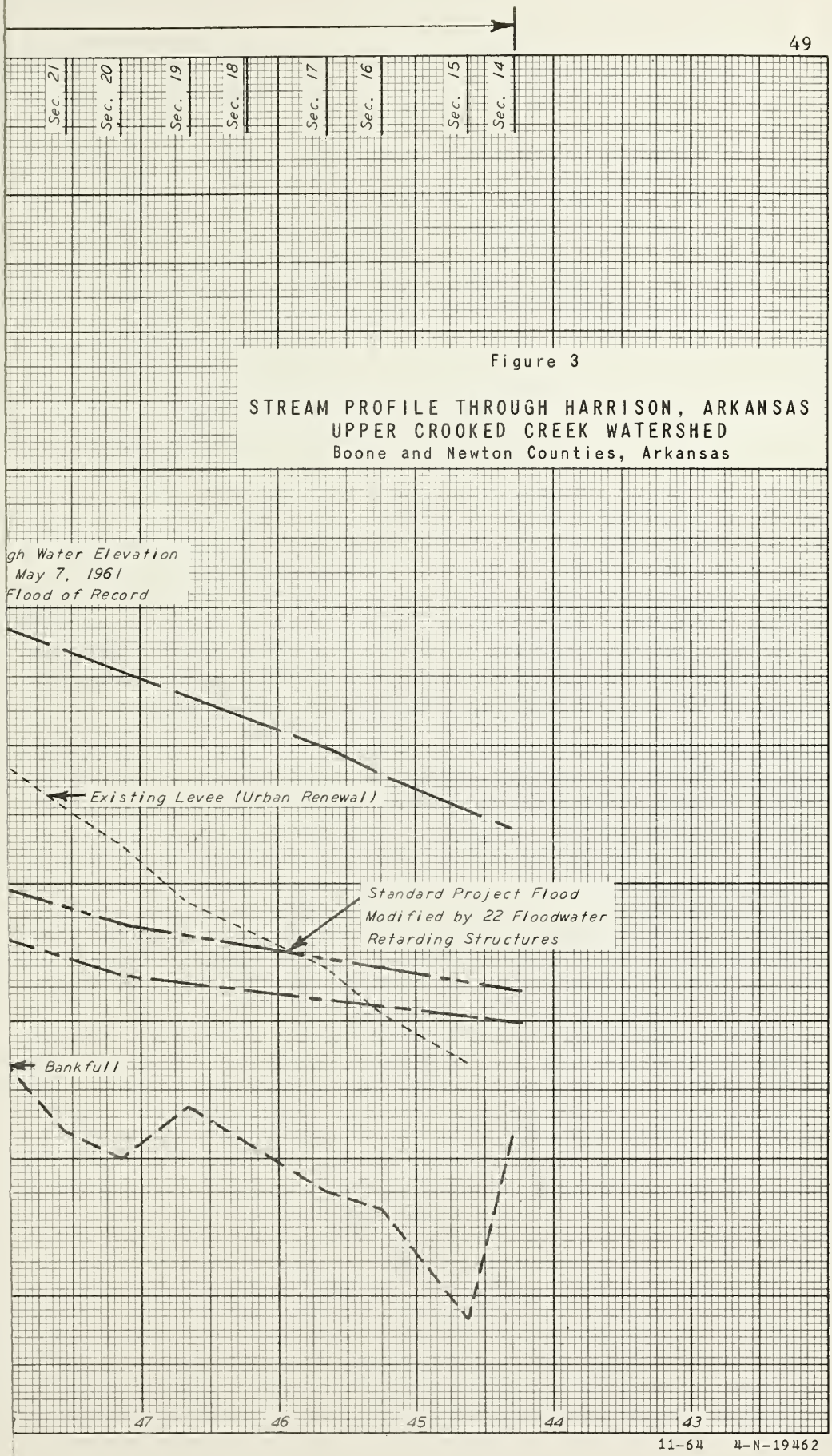


Figure 3

STREAM PROFILE THROUGH HARRISON, ARKANSAS
UPPER CROOKED CREEK WATERSHED
Boone and Newton Counties, Arkansas

Harrison, Arkansas

Sec. 38 | Sec. 37 | Sec. 36 | Sec. 35 | Sec. 34 | Sec. 33 | Sec. 32 | Sec. 31 | Sec. 30 | South Avenue Bridge | Sec. 29 | Little Dry Jordan | Sec. 28 | Highway 62 Bridge | Sec. 24 | Sec. 23 | Dry Jordan | Sec. 22 | Sec. 21 | Sec. 20 | Sec. 19 | Sec. 18 | Sec. 17 | Sec. 16 | Sec. 15 | Sec. 14

Deck
L. C.
Deck
L. C.

High Water Elevation
May 7, 1961
Flood of Record

Existing Levee (Urban Renewal)

May 7, 1961 Flood Modified by 22 Floodwater Retarding Structures

Standard Project Flood Modified by 22 Floodwater Retarding Structures

Existing Channel Bottom

Bankfull

Elevation In M.S.L.

1066
1062
1058
1054
1050
1046
1042
1038
1034
1030
1026

Channel Distance In Thousands of Feet

56 55 54 53 52 51 50 49 48 47 46 45 44 43

Figure 3

STREAM PROFILE THROUGH HARRISON, ARKANSAS
UPPER CROOKED CREEK WATERSHED
Boone and Newton Counties, Arkansas

11-64 4-N-19462

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Little Rock, Arkansas

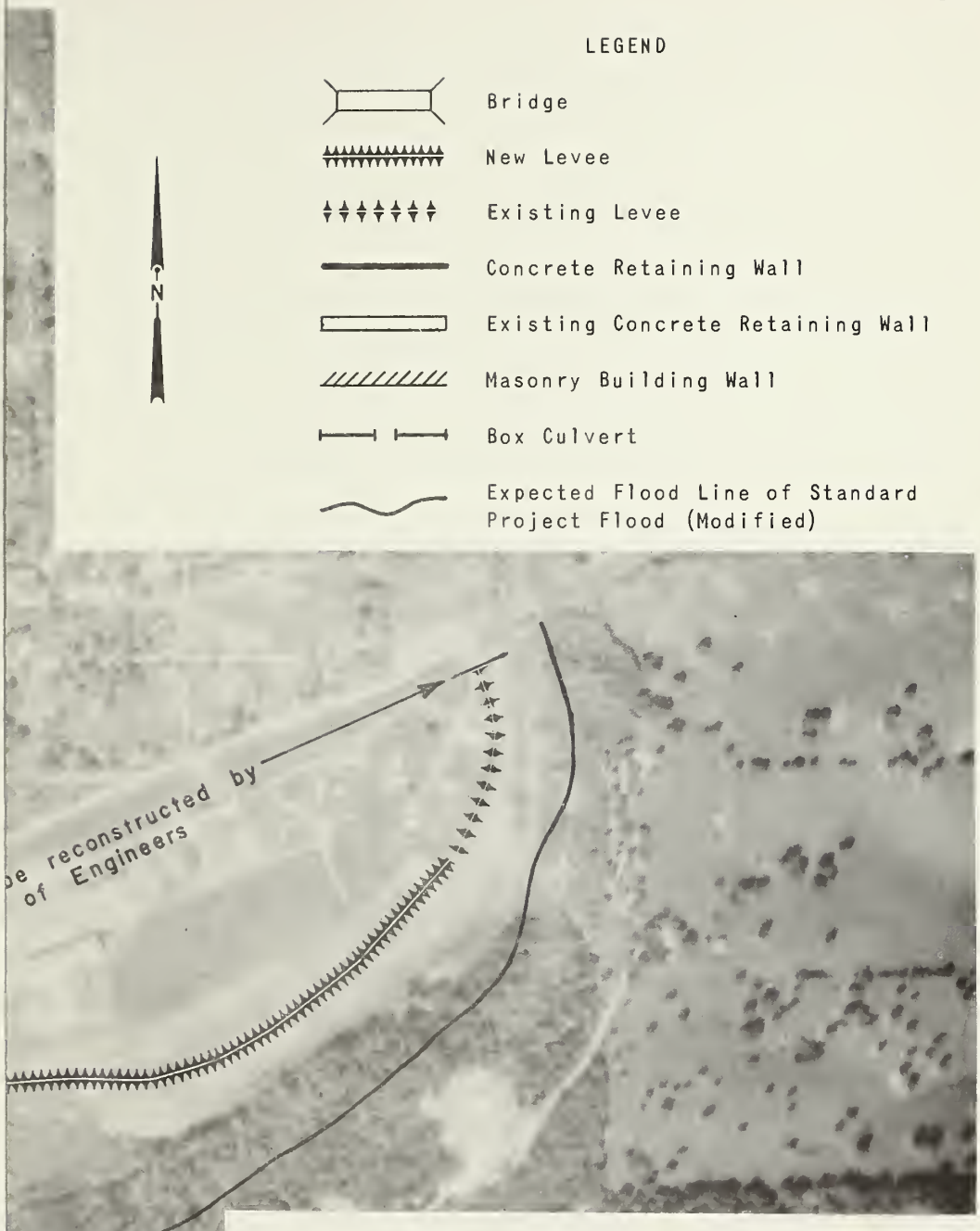


Figure 4

URBAN BENEFIT AREA
UPPER CROOKED CREEK WATERSHED
BOONE AND NEWTON COUNTIES, ARKANSAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
LITTLE ROCK, ARKANSAS

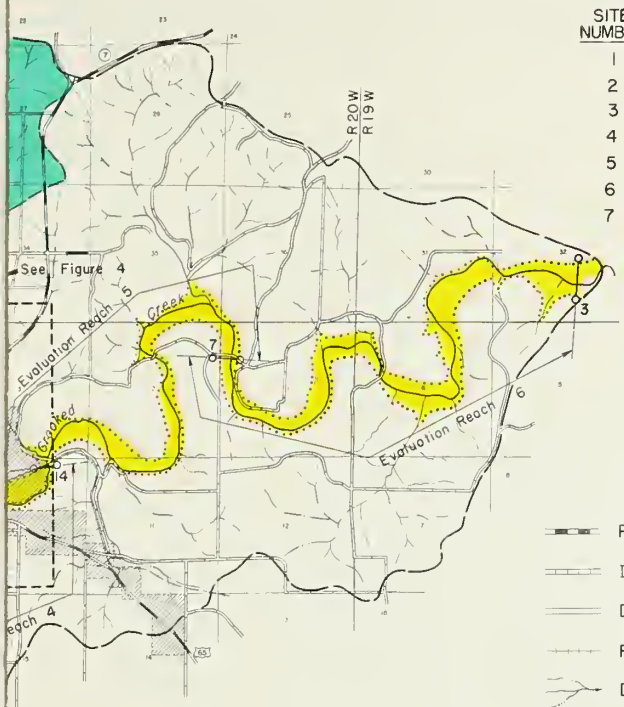
0 500 1000 1500 Feet
Approximate Scale

11-64 4-R-19500

Figure 4

URBAN BENEFIT AREA
UPPER CROOKED CREEK WATERSHED
BOONE AND NEWTON COUNTIES, ARKANSAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
LITTLE ROCK, ARKANSAS

11-64 4-R-19500



SITE NUMBER	DRAINAGE AREA-ACRES	SITE NUMBER	DRAINAGE AREA-ACRES
1	429	8	659
2	691	9	5494
3	2445	10	355
4	1798	11	365
5	2842	12	1082
6	1478	13	474
7	517	14	4134
		15	448
		16	497
		17	1242
		18	346
		19	851
		20	1460
		21	523
		22	2988

LEGEND

- Paved Road
- Improved Road
- Dirt Road
- Railroad
- Drainage
- Town or Community
- County Line
- Watershed Boundary
- Floodwater Retarding Structure
- (19) Structure Site Number
- Drainage Area Controlled by Structure
- Benefited Area
- 3 Valley Cross Section
- Evaluation Reach

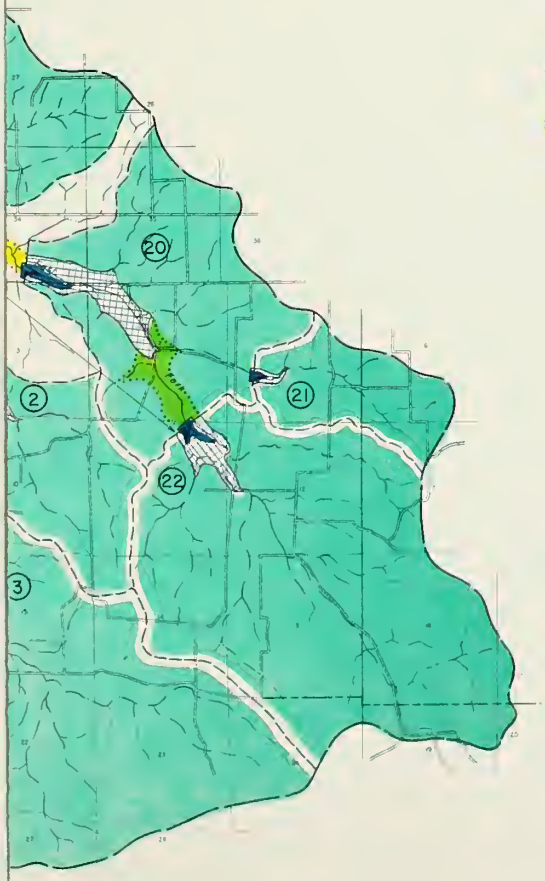


Figure 5

PROJECT MAP

UPPER CROOKED CREEK WATERSHED

BOONE AND NEWTON COUNTIES, ARKANSAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
LITTLE ROCK, ARKANSAS

Approximately Drainage Area 56,140 Acres

Revised 11-64 3-62 9-64
Revised 11-7-61 5-17-60

4-R-17309
Base 4-R-14576

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